1994 Report to the Congress on

Ballistic

Missile

Defense

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Prepared by the Ballistic Missile Defense Organization

This report is dedicated to the memory of Mr. David R. Israel who suddenly passed away on February 15, 1994. Mr. Israel, a 37 year employee of the Federal Government, served as the BMDO Deputy Assistant General Manager for Theater Missile Defense. Since the inception of this program three years ago, he worked tirelessly to make theater missile defenses a reality. His enthusiasm and devotion remain an inspiration to his colleagues.

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Strategy And Objectives

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1.0 Introduction

This year, the Annual Report to Congress consolidates into a single report a comprehensive discussion of the current program to develop ballistic missile defenses. The report specifically responds to the currently relevant requirements specified by the National Defense Authorization Act for 1990 and 1991 (Public Law 101-189) and the requirements imposed by Sections 235 and 236 of the FY 1994 National Defense Authorization Act.

In response to the annual reporting requirements of Public Law 101-189 this integrated document describes the overall Ballistic Missile Defense (BMD) strategy, describes the discrete programs and projects included in the overall effort, addresses international participation in BMD research, certifies compliance of planned development and testing program with existing arms control agreements, and provides details of current and planned funding for BMD. The reporting requirements uniquely related to the earlier SDI program directed at a phased deployment of defenses to counter a massive Soviet attack, although no longer germane, have been carefully considered in developing the report, but are not specifically addressed. These provisions include Section 224 (b) (3), (4), (7), (9), and (10) of Public Law 101-189. The Theater Missile Defense (TMD) Master Plan and the Limited Defense System (LDS) Development Plan chapters are structured to describe the current deployment planning strategy and together with the Technology chapter relate the ongoing research efforts to longer term deployment options.

Chapter 2 of the report is specifically structured to address Section 235 (b) of the FY 1994 National Defense Authorization Act, which requires a Theater Missile Defense Master Plan and the TMD testing program as required by Section 235 (c). It also comprehensively describes the current TMD program strategy, architecture, and planning requirements embodied in Public Law 101-189. The Arms Control Treaty compliance requirements statements required by Section 235 (d) are addressed in Chapter 6 of this report. Arms Control Treaty compliance reports for the TMD systems and Brilliant Eyes have also been submitted under separate cover. In response to the Section 235 (g) requirement for a "Review and Report on Deployment of Ballistic Missiles Defenses" a separate report on potential acquisition process streamlining opportunities for TMD systems, as well as their application to future acquisitions of systems for National Missile Defense, per Section 236 (b) (7), will be provided. As required in Section 239, a complete discussion of the Arrow tactical antimissile program developed jointly with the Government of Israel has also been presented in a separate report to Congress.

Similarly, Chapter 3 while specifically responding to the requirements in Section 236 (b) of the FY 1994 National Defense Authorization Act for a discussion of the development plan for a limited defense system providing National protection against ballistic missiles (with the exception of addressing acquisition streamlining per Section 236 (b) (7) as noted above), also addresses Public Law 101-189 requirements. The impacts on testing and contractor technical support resulting from the refocused BMD program, required by Section 236 (b) (8), are addressed in Chapter 5 regarding funding.

1.1 Background

Although conceived at the height of Cold War tensions, the United States Ballistic Missile Defense (BMD) is now structured to respond to the "here and now" theater missile defense threat and an uncertain, but evolving threat to the United States. The current structure is founded upon the President's endorsement of the 1993 Department of Defense "Bottom-Up" Review (BUR) and the Missile Defense Act of 1991 (MDA), as subsequently amended in Fiscal Year (FY) 1993 and 1994 National Defense Authorization legislation. The BUR, the President's endorsement, and the legislation call for United States adherence to the 1972 Anti-Ballistic Missile (ABM) Treaty, while emphasize the need for development of advanced theater missile defenses to meet the dangerous and growing theater ballistic missile threat.

As amended, the MDA:

- establishes a goal of complying with the ABM Treaty while developing, and maintaining the option to deploy a highly effective U.S. ABM system;
- directs development of advanced theater defenses;
- urges negotiation of ABM Treaty amendments that would clarify the distinction between theater and strategic missiles.

The FY 1993 National Defense Authorization Act established a Theater Missile Defense Initiative office within the Department of Defense. Considering the synergies between BMD and TMD technologies, the Secretary of Defense assigned the TMDI office to the Ballistic Missile Defense Organization (BMDO).

1.2 Current Guidance

The Defense Planning Guidance for Fiscal Years 1995-1999, signed September 28, 1993 states defense budgets will emphasize initiatives and strategies to meet four significant dangers that have emerged since the end of the Cold War and the collapse of the Soviet Union: nuclear weapons, other weapons of mass destruction, and the proliferation of these weapons and their delivery vehicles; regional dangers to U.S. interests; dangers to democracy and reform in the former Soviet Union and elsewhere; and economic dangers that threaten the prosperity of Americans. The BMD program contributes to negating the first significant danger through the TMD program. TMD will provide protection to American and allied deployed forces from theater ballistic missiles. Further, the BMD program addresses the danger of proliferation by (a) supporting traditional efforts (e.g. nonproliferation) with a military capability to actively defend U.S., allied and friendly interests from ballistic missile attacks and (b) enhancing deterrence, by providing capability to reduce the benefits a potential aggressor might realize from the employment of weapons of mass destruction.

In October 1993, the Department of Defense published the results of a comprehensive Bottom-Up Review of the nation's defense strategy, force structure, modernization, infrastructure, and foundations. The underlying premise of this review was that in light of the end of the Cold War and the dissolution of the Soviet Union, America's security needs had been fundamentally altered.

To meet today's growing threat from theater ballistic missiles, the Department decided to emphasize a core Theater Missile Defense (TMD) program plus an additional major acquisition. The core program included Patriot Advanced Capability-3 (PAC-3), AEGIS/Standard Missile-2 Block IVA (SM-2 Blk IVA), and the Theater High Altitude Area Defense (THAAD) system. The additional program was Sea Based Theater Wide Defense (formerly called Sea Based Upper Tier). This is Option 2 in the Report on the Bottom-Up Review dated October 1993. These programs were to be funded as major acquisitions in FY 1995-1999. Subsequent to the Bottom-Up Review, reductions in BMDO funding changed the Sea Based Theater Wide program from a major acquisition in FY 1995-1999 to a candidate concept to be considered, along with Boost Phase Intercept and Corps SAM, for a major acquisition new start in FY 1998. Since the announcement of the BUR, the Department has removed $1.1 billion from the BUR estimate that $12 billion would be needed in FY 1995-1999 to implement the TMD program.

Because there is a danger that a long-range missile threat to the United States may emerge in the future, the Department decided to conduct a technology readiness program for National Missile Defense (NMD) that would develop and maintain options for contingency deployment. The NMD technology readiness program will require approximately $3 billion over the years FY 1995-1999.

Also, continued research of advanced BMD technologies along with continued support of an integrated joint Service effort was determined to be prudent, and the Department decided to devote approximately $3 billion to such activities over the years FY 1995-1999.

Congressional guidance regarding the BMD program was modified by the FY 1994 National Defense Authorization Act which read, in part, "It is a goal of the United States to.... comply with the ABM Treaty.... while developing, and maintaining the option to deploy, an anti-ballistic missile system that is capable of providing a highly effective defense of the United States against limited attacks of ballistic missiles;.... and.... provide highly effective theater missile defenses (TMDs) to forward-deployed and expeditionary elements of the Armed Forces of the United States and, as appropriate, to friends and allies of the United States."

The Act also requires the Secretary of Defense to "(1).... develop advanced theater missile defense systems for deployment in compliance with the ABM Treaty.... [and] (2).... conduct a research and development program to develop and maintain the option to deploy a cost-effective, operationally effective, and ABM Treaty-compliant antiballistic missile system at a single site..."

Finally, while recognizing that space based sensors can play a future role for both TMD and NMD, the Congress mandated that the Brilliant Eyes (BE) program should be examined along with USAF funded space based sensor programs and consequently moved FY 1994 BMDO funds for BE into an Air Force managed Program Element (PE).

1.3 Program Priorities

The emerging threat of primary concern in today's post Cold War world is the proliferation of theater ballistic and cruise missiles armed with weapons of mass destruction. Ballistic and cruise missile deployments are expected to increase worldwide, and a number of countries have or are developing nuclear, chemical and/or biological weapons that could be delivered by these systems. In the near term, this proliferation threat is largely regional in nature, but the range capabilities of new systems are steadily increasing.

With regard to the strategic threat, current intelligence assessments have placed an extremely low probability on a deliberate attack on the United States by the states of the former Soviet Union or by China. Accidental or unauthorized launches of former Soviet or Chinese nuclear missiles are also considered unlikely. However, the possibility of a limited, long-range ballistic missile threat from the Third World sometime in the first decade of the next century cannot be excluded.

Consequently, regional missile threats have become the major focus of BMD planning. But while the requirement for theater missile defense dominates, there remains a need to develop options to negate limited ballistic missile attacks against the United States.

The Department's planning is structured to vigorously pursue the acquisition of theater missile defense systems, while concurrently conducting a research and development program that will support an option to expeditiously deploy national missile defenses. Promising advanced technologies that provide significant added BMD performance capabilities especially in response to an adversary's potential countermeasures will also be investigated. This balanced approach is fully responsive to the Congressional guidance summarized above.

1.3.1 Theater Missile Defense

Goals for TMD have been formulated in terms of five broad capability areas:

- A lower tier (terminal, endoatmospheric) intercept capability with both air transportable and sea deployable capabilities to defend point and limited area asset targets, and to protect mobile ground forces.

- An upper tier (midcourse, high endo/low exoatmospheric) intercept capability with both air transportable and sea deployable capabilities to extend intercept envelopes, provide broader area defense, assure multiple intercept opportunities, and minimize the ground effects of unconventional weapons.

- Enhanced warning and surveillance capabilities including fixed and mobile tactical processing of launch detection data (from the Defense Support Program (DSP), space early warning systems, or other means), extended midcourse tracking, and netted surveillance to support intercepts and broader defense coverage.

- Battle Management/Command, Control, Communications and Intelligence (BM/C^3I) capabilities to tie together and manage the intercept and surveillance/warning capabilities and to coordinate TMD functions with the ballistic missile defense elements, under study, as part of the NMD.

- Capability for boost phase intercept to destroy missiles equipped with weapons of mass destruction, countermeasures and/or clustered warheads before their release or to destroy attacking missiles over the attacker's territory.

In the near term, an enhanced lower tier intercept capability will be provided by the PATRIOT Advanced Capability-2 (PAC-2) with Quick Response Program (QRP) enhancements and improvements to the AN/TPS-59 Radar and HAWK Weapon System. In the core program, lower tier intercept capability will be bolstered by PATRIOT PAC-3 and modifications to the AEGIS system, including the SPY-1 Radar and Standard Missile 2 (SM-2) Block IVA; and an upper tier intercept capability will be established with the THAAD missile and the TMD-GBR. Concepts for Corps SAM to further improve and extend to maneuver forces the lower tier intercept capability to protect mobile ground forces; Sea Based Theater Wide Defense systems; and Boost Phase Intercept (BPI) are being considered and the deployment of one or more of these systems will occur after completion of the core program deployment. Each of these concepts is explained in more detail in Chapter 2 of this plan.

1.3.2 National Missile Defense

The priority for NMD is to resolve key element and system level technical challenges which lead to the development and maintenance of options to deploy ballistic missile defenses for the U.S. should a threat emerge in the future. The focus of NMD is to develop and mature these critical technologies incrementally. This results in increasingly capable options for deployment based on technologies matured as a result of the investments made in this program. In accordance with this priority, the NMD program will be structured as a technology readiness program developing significant additional BMD capability to be available for possible contingency deployment.

Prior to the BUR decision, the NMD program was structured as an acquisition program aimed at defending against a Global Protection Against Limited Strike (GPALS) sized threats (up to as many as 200 Reentry Vehicles). Deployment of a first site was at least ten years away, and contingency deployment was not planned. Multiple sites were envisioned for the objective system, and relief from ABM Treaty constraints would have been required. The change in priority and direction for the NMD program coming from the BUR reflects the changes in the threat environment from the earlier GPALS threat. The new NMD strategy accommodates the lowered priority and reduced level of funding. It also allows an evolution of capability as technology matures. The Technology Readiness Program will also allow contingency deployment of an NMD system based upon the best technology available as a result of the NMD Technology Readiness Program and other relevant R&D efforts in BMDO and the Services. Details of the readiness program are addressed in Chapter 3 of this report.

1.3.3 Advanced Technologies

With a longer range perspective, BMD advanced technology efforts seek to develop and demonstrate affordable, high payoff technologies to support the deployment of TMD and the development of technologies for NMD. These technologies are selected for their potential for reducing costs and providing significant added performance capabilities to maintain a defense posture capable of countering evolving ballistic missile threats -- threats which are increasing in both number and sophistication. While we shift the focus and vision of ballistic missile defense to acquire theater missile defense systems that meet today's requirements, we must not neglect potential future threats and the technology needed to counter them. In essence, they are the advanced technologies that are essential to meeting the BMD mission in the future.

The principal areas of advanced technology development being pursued are directed and kinetic energy weapons primarily for boost phase intercept; exo- and endoatmospheric intercept with high probability of kill at lower cost using advanced kinetic interceptors; and advanced sensor development. Advanced sensors are required to monitor developing threats, detect surprise attacks or evolving threats during the early stages of rapidly escalating conflicts; acquire, identify, track, and discriminate targets; and provide accurate kill assessments. Chapter 4 of this report further describes the advanced technologies program.

1.4 Management Approach

The Department has assigned to BMDO the mission to develop for fielding, militarily effective defenses against ballistic missiles. To accomplish this mission, BMDO provides central BMD management, defines the system architecture and design, integrates requirements and technology, develops budgets and allocates resources, ensures integration with other U.S. and international defense capabilities, ensures systems are interoperable, and coordinates theater missile defense with national missile defense. In response to BMDO top level guidance and direction, and in consonance with DOD policy and guidance, the Services are responsible for program execution.

The Joint Chiefs of Staff (JCS), in conjunction with area Commanders In Chief (CINCs), formulate the operational concepts; coordinate and validate mission needs and operational requirements; provide liaison with associated allied commands; establish command and operational control doctrines for resources assigned; and, establish command relationships, force structures and assets, protocols, and rules of engagement. The CINCs also identify TMD requirements in their theater of operations.

The Services develop operational requirements; manage TMD programs; provide program analysis and support; conduct or participate in development, test, and evaluation of BMD programs; conduct operational test and evaluation; and plan for, support, and fund programs after their transition to Service responsibility including production, deployment, training, operations, and support.

While this management arrangement, where each of the Services manages specific programs which are integrated by BMDO to satisfy users' requirements, makes the best use of the Department's collective talent, BMDO is responsible for providing an affordable and sustainable BMD capability to the warfighter.

Chapter 2

Theater Missile Defense Master Plan

Chapter 2
Theater Missile Defense Master Plan

2.1 Introduction

In June 1993, the Department of Defense forwarded the master plan for the Theater Missile Defense Initiative (TMDI) to Congress. This section, developed specifically in response to Section 235 of the FY 1994 National Defense Authorization Act, also updates the June 1993 TMDI master plan. Arms Control Treaty requirements for Theater Missile Defense programs are addressed in Chapter 6 of this report.

2.2 Mission and Scope

The Theater Missile Defense Mission Need Statement (MNS) defines the mission and scope of theater missile defense. It states, "The mission of TMD is to protect U.S. forces, U.S. allies, and other important countries, including areas of vital interest to the U.S., from theater missile attacks." The TMD mission includes protection of population centers, fixed civilian and military assets, and mobile military units.

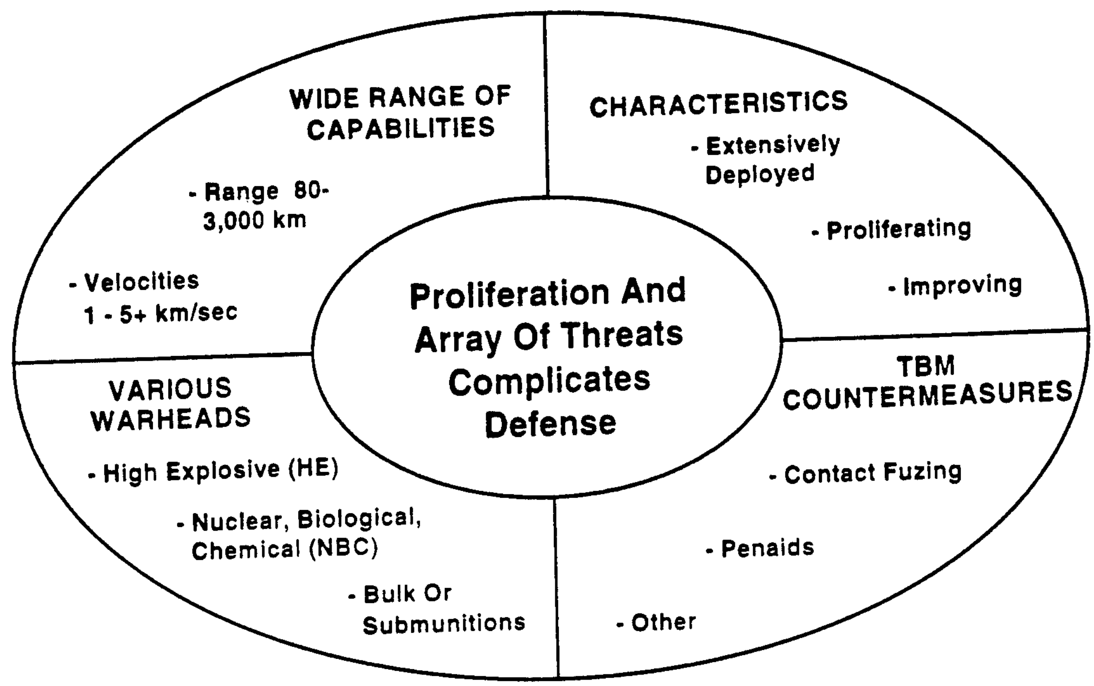
The MNS also provides a basis for defining the scope of the program. The MNS identifies four "pillars" of TMD: attack operations, active defense, passive defense, and command, control, communications, and intelligence (C^3I). The scope of the BMDO TMD program is to focus on active defense and the associated C^3I. The MNS defines a Theater Missile (TM) as "ballistic missiles, cruise missiles, and air-to-surface missiles." BMDO has concentrated on the ballistic missile threat while the Services have continued to develop counters to the other TMs. Because TMD against ballistic missiles also has a capability against cruise and air-to-surface missiles, BMDO is working closely with the Services to investigate ways to counter all three types of TMs. However, active defense against the ballistic missile remains the focus of the BMDO TMD effort.

2.3 Threat

The Theater Ballistic Missile (TBM) threat continues to evolve; however, the technologies involved are well understood and have been described in various threat documents. Figure 2-1 presents a general view of the TBM threat and is described below.

Currently, mature design TBMs are extensively deployed and, because of their low cost and availability, they are proliferating throughout the world. TBMs have a wide range of capabilities depending on the technologies involved and the cost a particular nation is willing to pay. Adding to the threat complexity are the various warheads including high explosives, bulk or submunitions, and weapons of mass destruction (nuclear, biological, and chemical). The evolving threat may also be expected to employ countermeasures to reduce the effectiveness of TMD systems. Thus, the array of TBM threats and their proliferation significantly complicates the theater missile defense mission.

Figure 2-1. Existing Theater Ballistic Missile Threat



2.4 Doctrine, Tactics, Training, and Force Structure

2.4.1 Joint Doctrine

Significant progress has been made in formalizing the joint doctrine for theater missile defense. Two specific areas that have received much attention are the Commanders in Chief (CINCs) TMD Experiments Program and the Joint Publication 3-01.5, Doctrine for Joint Theater Missile Defense. The CINCs TMD Experiments Program is discussed in Section 2.7.5. and the following discusses joint doctrine.

Joint Publication 3-01.5, Doctrine for Joint Theater Missile Defense sets forth doctrine that governs the activities and performance of the Armed Forces in joint operations as well as U.S. military involvement in multinational and interagency operations. A draft update is currently under review and is expected to be approved this year. When approved, it will provide military guidance for the exercise of authority by combatant commanders and other joint force commanders, and prescribe doctrine for joint operations and training.

The following paragraphs, present the respective Army, Navy, and Air Force doctrine, tactics, training, and force structure regarding operational aspects of theater missile defense.

2.4.2 Army

The Army supports the national military strategy of defense against theater missile attacks by protecting forces, facilities, and population centers; conducting precision strikes with deep strike assets such as Extended Range Army Tactical Missile System (ATACMS) and Army air assets to destroy enemy launch capabilities; and dominating the maneuver battlefield. Virtually all operational scenarios include the deployment of Army TMD forces as part of a joint forces defense. Precision strikes against opposing missile launch capabilities help theater CINCs project and sustain the force safely by defending air and sea ports of debarkation and lines of communication against TBM interdiction. Army TMD also allows CINCs to dominate maneuver operations by protecting maneuver forces and designated critical assets.

Evolving Army TMD doctrine calls for a highly capable and robust ground based defense that is rapidly deployable and sustainable in contingency theaters to support force projection operations. This doctrine will coincide with joint service TMD doctrine and operational principles included in Joint Publication 3-01.5, Doctrine for Joint Theater Missile Defense. The authoritative foundation for subordinate Army doctrine is the Army Field Manual, FM 100-5, Operations, which recognizes that the threat to friendly forces has grown due to weapons of mass destruction and the proliferation of missile technology. In defining the requirement for force protection in each phase of an operation, FM 100-5 identifies a greater role for theater missile defense in the generation of combat power. It describes how a PATRIOT and Theater High Altitude Area Defense (THAAD) task force will operate to provide a two tiered defense of critical assets within a theater. Specific "how to fight" tactics are emerging with doctrine evolving from lessons learned in the Gulf War and from ongoing wargaming and analysis efforts. Doctrine and tactics for Corps SAM will mature if Corps SAM is developed as a follow-on capability.

Steps to increase leader and soldier proficiency in TMD will include incorporating the TBM threat and TMD responses into all levels of training and service school programs of instruction, as well as capturing and understanding the lessons learned from recent combat experience. TMD will be an integral part of the live field training exercises at the combat training centers and the battle labs. TMD will be examined in detail to provide the best possible combat preparation for commanders, staffs, and soldiers.

The current and programmed PATRIOT force includes 88 firing batteries (or fire units). Of these, 44 comprise the nine operational PATRIOT battalions, four are being prepared for transfer to the National Guard, and six are being used for Southwest Asia rotation. The remaining 34 are either manned by German forces or are used for training and maintenance support. The PATRIOT force will begin upgrading to the final PATRIOT Advanced Capability–3 (PAC-3) configuration beginning in FY 1998.

Two THAAD battalions, each with four firing batteries, will begin fielding early in the next decade. The THAAD program will also deliver a functional, developmental prototype system at the end of Demonstration/Validation (Dem/Val). This system, referred to as the THAAD User Operational Evaluation System (UOES), will provide early deployment proficiency training and Engineering and Manufacturing Development (EMD) testing. In the event of a national emergency, the UOES can provide a deployable prototype system by FY 1997. These units will be based at Fort Bliss, Texas and could be rapidly inserted into any theater using current military transport aircraft.

2.4.3 Navy

The new world order emphasizes the need for naval forces that can operate in any littoral theater, in any mission, first to provide a forward presence and initial capability when no other assets exist and, if necessary, to participate in joint expeditionary warfighting. Accordingly, the Navy's role in the post Cold War era has become prompt and sustained combat operations that are not so much "on the sea" as "from the sea."

The inherent mobility of naval forces and their capability for integrated warfighting make them an important foundation for CINC contingency planning and phased response to regional crises. They are capable of creating an immediate multi-warfare defensive umbrella against all threats to expeditionary forces as they assemble and move from the sea to the shore. If forced entry is required, the Navy's role will be to provide highly survivable active defense, complemented by attack operations against enemy missile sites and other key targets. As joint forces continue to build and begin to move inland, the Navy's role will expand to include managing and defending the logistics train, as well as extending the reach of attack operations.

Operational, doctrine, and training commands are concurrently updating Concepts Of Operations (CONOPS) (including command and control). The revised CONOPS will be incorporated in shore and sea based training. Within a theater level architectural perspective, all functional areas, from intelligence and surveillance to post engagement assessment, are being scrutinized for optimum effectiveness in joint operations. All efforts are being controlled by operational demonstrations and experiments that verify progress in system engineering and doctrine evolution. Operations of selected fleet units are addressing key areas of TMD in preparation for incorporating TMD in training and readiness exercises.

The Navy program is based on evolving the capabilities of the AEGIS weapon system to support increasing intercept capability against TBMs. The first stage of this evolving capability is called the Sea Based Area TBMD program. It provides for the combat system modifications for AEGIS to support TBMD and for modifying the Standard Missile-2 to the Block IVA TBMD configuration. This area defense program provides a lower tier or endoatmospheric intercept capability. The second evolutionary stage of the Navy program couples the combat system modifications developed for area defense with the development of an exoatmospheric (or upper tier) interceptor to provide theater wide capability. TBMD capability upgrades will be fully integrated with the AEGIS multi-mission capability in all four pillars of TMD.

The Navy plans to achieve a sea based area theater ballistic missile defense contingency capability in 1997 with a UOES on at least one AEGIS ship. The test and evaluation of the UOES in conjunction with testing at shore engineering support activities will provide significant opportunity for further development and validation of doctrine and tactics in both Navy and joint environments.

2.4.4 Air Force

The Air Force plays a vital role in providing a TMD capability to the theater CINCs. TBMs pose a unique challenge, that, in accordance with Joint doctrine, are defended by integrating a mix of mutually supportive passive defenses, active defenses, attack operations, and Command, Control, Communications, and Intelligence measures. As such, they are a target subset of the Joint Force

Commander's (JFC) overall campaign. The Air Force contributes to the campaign through offensive and defensive counter-air, air interdiction, and strategic attack operations.

The air defense criteria to detect, identify, intercept, and destroy aircraft and associated support infrastructure in a theater remains the same for theater missiles. The reduced command and control time inherent in theater missile operations requires improved sensor target detection and identification capability, a joint Battle Management/Command, Control and Communication (BM/C^3) architecture, and faster execution of command and control functions. The connectivity between Services must allow for diverse alternatives and many opportunities to negate the TBM threat. Procedures and training must be established prior to the start of a theater conflict to ensure the greatest efficiency of a multilayered TMD capability. The theater missile threat requires real-time target detection, retargeting, and weapon-target pairing capability. Attacking mobile targets within minutes and seconds must be the norm and requires full integration of all assets.

Because the Air Force, like the Navy, may be the first force to arrive in a theater, the importance of having an air launched capability against ballistic missiles cannot be overlooked. OSD and the Joint Staff have conducted several reviews of potential ballistic missile defense systems and have approved a demonstration of a boost phase intercept capability. This effort is being led by the Air Force with Navy participation and is being jointly funded by the Air Force and BMDO.

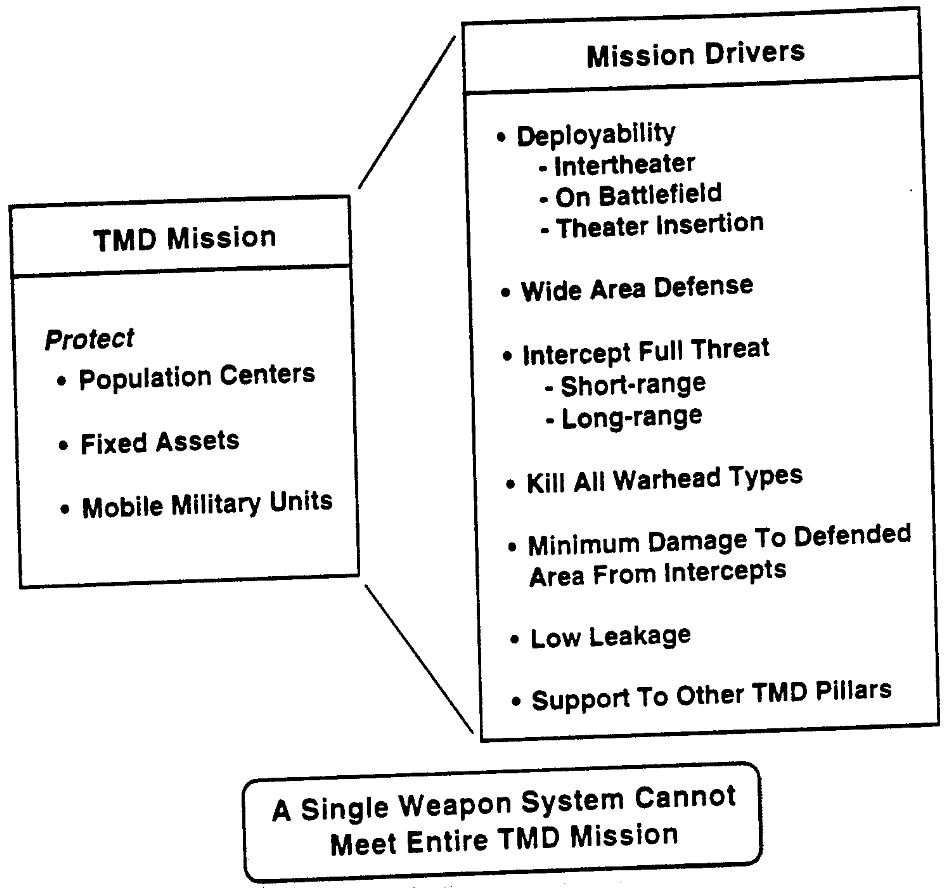
The Air Force provides assets and significant capabilities to the Joint Forces Commander to locate, identify, and destroy/deny an enemy's theater missile capability before it can threaten friendly forces, critical assets, or areas of vital interest. The Air Force in concert with the Component Commanders and in accordance with Joint Publication 3-01.5, will focus on attacking theater missiles in the boost phase after launch or on the ground during the pre-and post launch phase and disrupting the enemy's missile operations with an appropriate balance of joint assets. Space support and theater sensor data must meet reduced time lines, with more accurate target detection, identification, and tracking data for TBM targets in the air or on the ground. Active defense in the terminal phase and passive defense enable the JTF to mitigate the destructive potential of theater ballistic missiles that are not destroyed by counterforce and boost phase interceptors.

2.5 TMD Active Defense Framework

The 1993 TMDI Report to Congress presented a framework and architecture that were developed from operational and technical attributes. As TMD doctrine has evolved, we have modified the framework to respond to the developing doctrine. BMDO continuously evaluates the TMD mission, threat characteristics, and doctrine and updates the mission drivers and desired TMD performance characteristics. This continuous process ensures that the framework and architecture meet the TMD system requirements. Figure 2-2 shows the TMD mission and resultant mission drivers. No significant changes have occurred in the past year, and the primary conclusion, "a single weapon system cannot meet the entire TMD mission," remains valid.

From the mission drivers, key performance characteristics of the TMD system are derived. Figure 2-3 shows the resultant performance characteristics. An examination of the performance characteristics leads to the conclusion that an upper and lower tier TMD system consisting of land, sea,

Figure 2-2. The TMD Mission And Mission Drivers

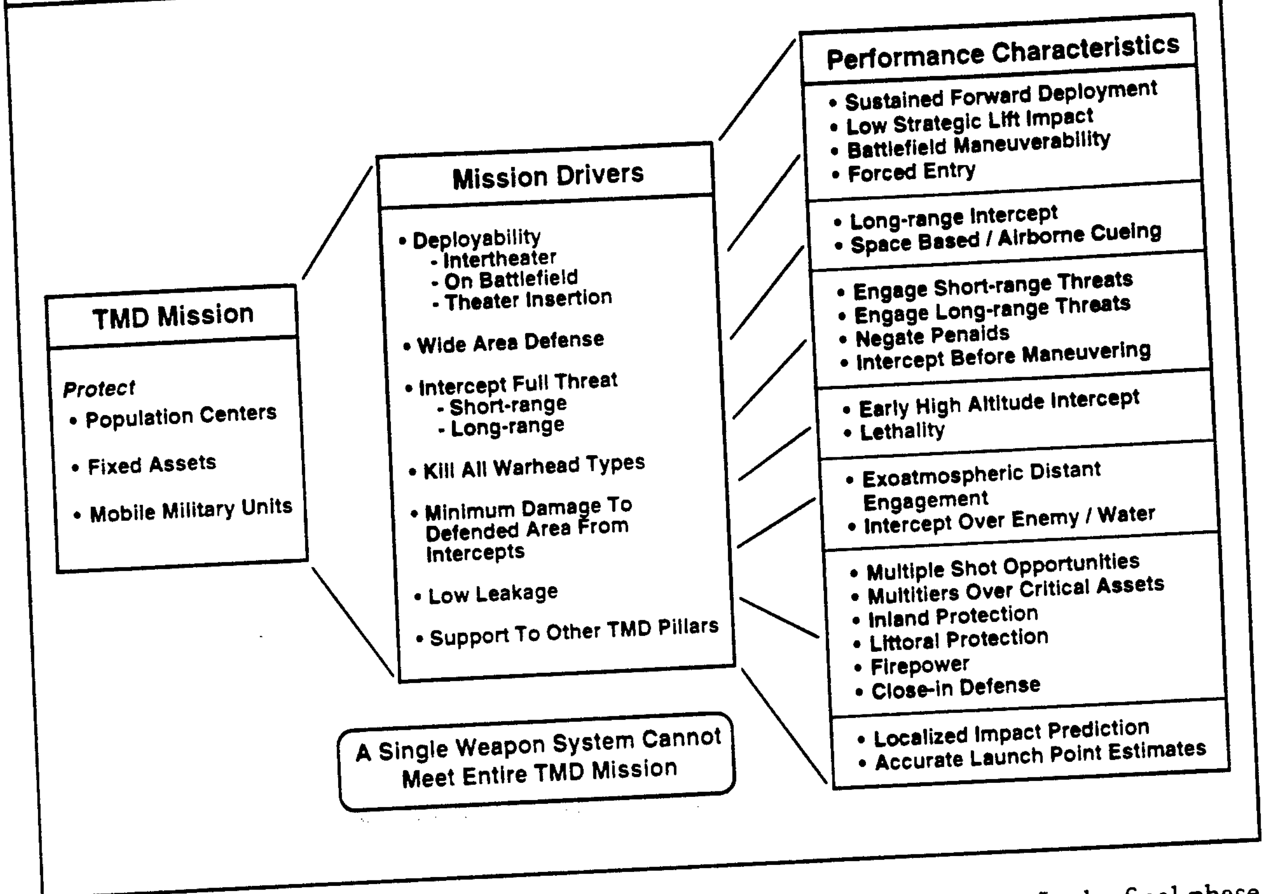


and air forces provided the most effective framework for TMD. This, then, becomes the updated TMD framework. This framework is similar to that submitted in the 1993 TMDI Report to Congress but is updated to reflect the evolving doctrine. Figure 2-4 shows the framework and associated performance characteristics. Note that BM/C^3 is a critical element which ties the other elements together.

2.6 Acquisition Strategy

The TMD acquisition strategy can be described as three phases. The first consists of the aggressive pursuit of near term improvements by enhancing existing systems using low risk, low cost, and quick reaction programs while simultaneously developing and refining TMD concepts of operation and tactics. The second phase employs a prudent acquisition approach to provide a significant core TMD capability. This core capability consists of land based defenses to protect critical assets and to provide theater wide protection. The core capability also includes a sea based defense to protect U.S. and friendly forces in ports and littoral areas. The core program utilizes user operational evaluation systems to provide an early contingency capability. A critical element

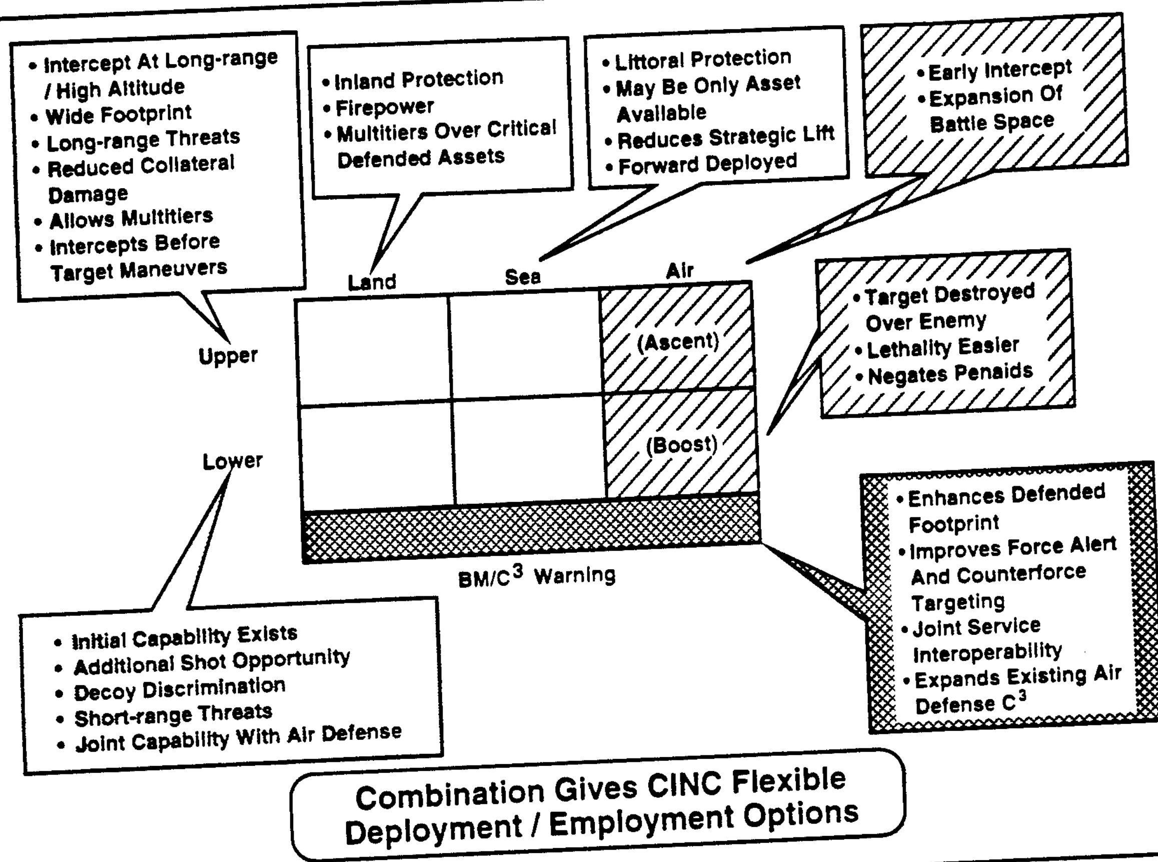
Figure 2-3. The TMD Mission Derived Performance Characteristics



of the core program is to establish an effective and joint BM/C^3 architecture. In the final phase, advanced concept technology demonstrations and other risk reduction activities are used to develop capabilities to complement the core program with the emphasis on affordability and new technologies. These future capabilities are called "advanced concepts."

The TMD acquisition strategy includes the operational employment of systems developed during the Demonstration/Validation (Dem/Val) and Engineering and Manufacturing Development (EMD) phases of the acquisition process. These User Operational Evaluation Systems (UOES) serve four purposes: (1) influence the engineering and manufacturing development program by getting users involved early; (2) provide systems for testing, evaluating, and training as part of the normal acquisition process; (3) refine operational doctrine and organizational structures; and (4) provide a contingency defense capability should the need arise in an emergency prior to production and deployment. The acquisition programs for THAAD and Sea Based Area TBMD include provisions for UOESs.

Figure 2-4. TMD Active Defense Framework



2.7 Near Term Improvements

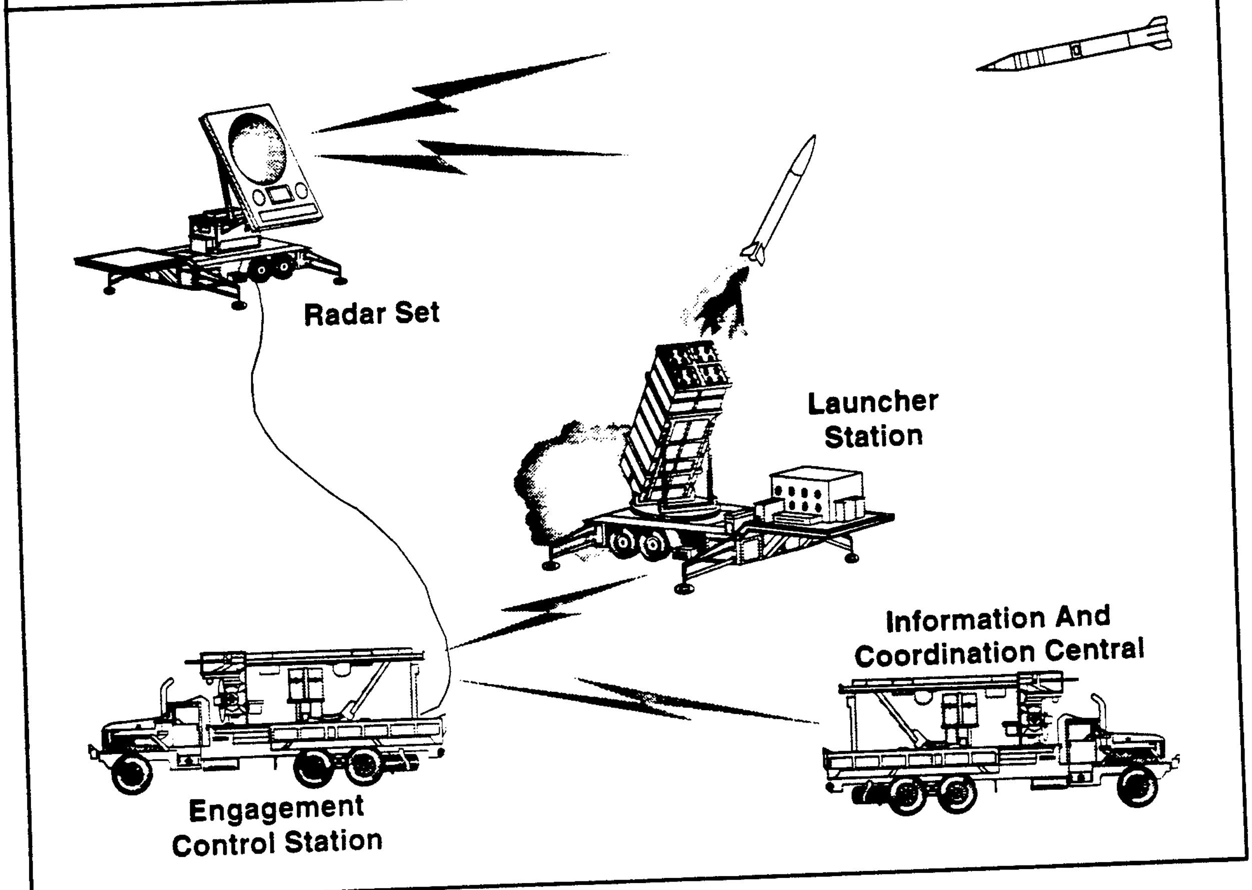
Near term efforts will provide improved theater missile defense until the core program capabilities are available at the end of the decade. Included are: PATRIOT Advanced Capability-2 (PAC-2) upgrades, TPS-59 radar and Hawk modifications, launch detection improvements, sensor cueing upgrades, and the CINCs TMD Experiments Program.

2.7.1 PATRIOT Anti-Tactical Missile Capability-2

The baseline for TMD is PAC-2. Near term upgrades include the Quick Reaction Program (QRP) and a Guidance Enhancement Missile (GEM) improvement. These upgrades will be followed by a series of upgrades under the PATRIOT Advanced Capability-3 (PAC-3) Program.

PATRIOT is an air defense guided missile system designed to cope with the air defense threat of the 1990s. The threat is characterized by defense suppression tactics using saturation, maneuver, and Electronic Countermeasures (ECM). The principal element of the PATRIOT organization is the battalion that consists of up to six firing batteries. Battalions normally deploy at echelons above corps and as part of the corps air defense artillery brigade. The PATRIOT battery, also referred to as a Fire Unit (FU), is the smallest element capable of engagement operations. The battery, shown in Figure 2-5, includes the Fire Control Section (FCS) and normally eight Launch-

Figure 2-5. PATRIOT



ing Stations (LS) although a battery has the capability to control 16 LSs. The FCS consists of a radar set (RS), Engagement Control Station (ECS), and Electric Power Plant (EPP).

The need for an Anti-Tactical Missile (ATM) capability was identified in the 1980s from the deployment of large numbers of accurate Soviet Tactical Ballistic Missiles (TBM) in eastern Europe. The PATRIOT Anti-Tactical Missile Capability-1 (PAC-1) and PAC-2 programs were developed to provide the PATRIOT system with additional capabilities to defend itself and critical assets against TBM threats and continue to carry out its primary mission.

The PATRIOT Quick Response Program (QRP) was instituted in 1991-1992. This program, designed to identify and quickly field improvements to correct Desert Storm shortcomings, includes emplacement upgrades for rapid, accurate fire unit emplacement, a capability to remote launchers up to 12 km from the radar, and radar enhancements to improve TBM detection and increase system survivability. The QRP configuration of PATRIOT is already deployed and operational in Saudi Arabia. A companion program, the Guidance Enhancement Missile (GEM), includes engineering improvements to the PAC-2 missile to improve lethality, especially against the Desert Storm class of TBM threats. Limited quantities of GEMs will be fielded in 1995.

- FY 1993 efforts resulted in the following accomplishments:
  - Completed the fielding of the first QRP battalion;
  - Conducted two GEM flight tests.

- Work planned for FY 1994:
  - Continue fielding QRP battalions;
  - Complete GEM flight tests and conduct production decision review.

- Work planned for FY 1995:
  - Complete QRP fielding;
  - Begin GEM delivery.

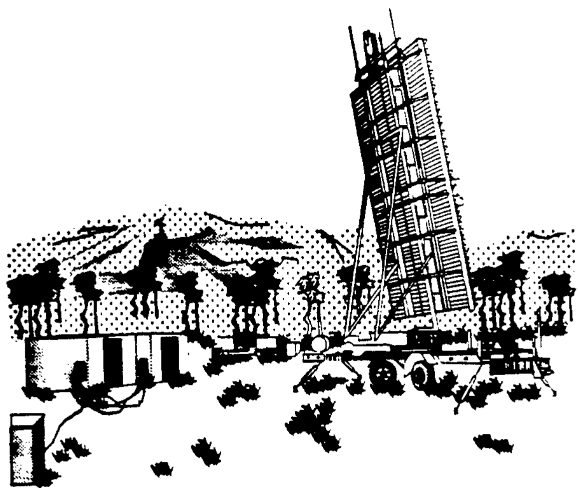
2.7.2 TPS-59 Radar and HAWK Modifications

TPS-59 radar and HAWK weapon system improvements will provide a TMD capability for U.S. Marine Corps (USMC) operations. This Marine Corps' TMD initiative is jointly funded with BMDO and will yield a low risk, near term capability for expeditionary forces against Short Range Ballistic Missiles (SRBM). This improvement consists of upgrades and modifications to the primary sensor (TPS-59 radar) and the weapon system (HAWK), and a communications interface between the two, the Air Defense Communications Platform (ADCP). Modifications to the TMD mode of the TPS-59 radar, summarized in Figure 2-6, will result in TBM target detection ranges out to 400 nautical miles and 500,000 feet in altitude. These modifications will provide cueing information to other theater weapon systems via a Joint Tactical Information Distribution System (JTIDS) link located in the ADCP.

The modified HAWK battery command post will process cueing data for control of the high-power illuminator radar as required. The ADCP converts TPS-59 data messages and TADIL-J formatted messages into the intra-battery data link formats required by the HAWK weapon system. Other HAWK upgrades will provide increased mobility and improvements to the digital launcher, and fuse and warhead changes to the missile. Technical, developmental, and operational testing is scheduled for FY 1996 with first units equipped late in the year.

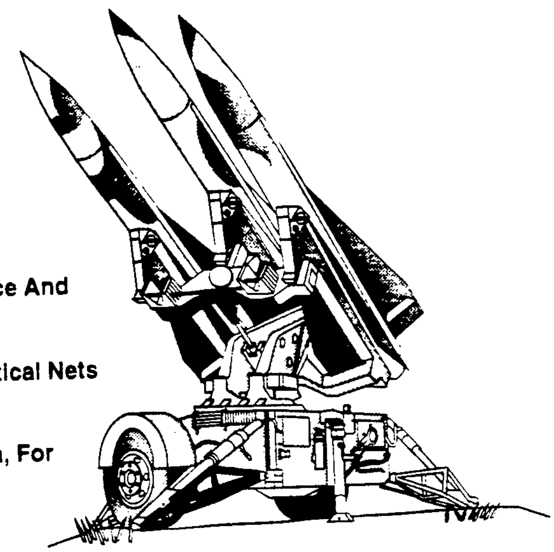
Under the current USMC force restructuring plan, one active duty HAWK battalion and one reserve HAWK battalion will be retained. The former will consist of three batteries, each with 12 launchers. The latter will be equipped with two batteries, each with eight launchers. Three missiles can be mounted on each launcher.

Figure 2-6. TPS-59 And USMC HAWK



USMC Funded

- Upgrade Of HAWK Launcher To Interface With Digital Missiles
- Upgrade Of HAWK Launcher To Increase Mobility



BMDO / USMC Jointly Funded

- Upgrade TPS-59 To Provide Enhanced TBM Surveillance And Tracking Capability
- Air Defense Command Post To Act As A Node For Tactical Nets
  - Make TPS-59 Data Available On A JTIDS Net
- Modify Battery Command Post To Accept TPS-59 Data, For Acquisition By HAWK Illuminator Radar
- Upgrade HAWK Missile Fuze And Warhead For TBM Engagements

- FY 1993 efforts resulted in the following accomplishments:
  - Conducted TPS-59 system design review and began hardware fabrication and software development;
  - Awarded contracts for the HAWK TMD modifications and Air Defense Communications Platform software development.

- Work planned for FY 1994:
  - Begin TPS-59 system integration effort;
  - Conduct HAWK TMD software Initial Developmental Test and Evaluation;
  - Complete Air Defense Communications Platform Milestone I and II reviews;
  - Conduct Air Defense Communications Platform hardware and software preliminary and critical design reviews.

- Work planned for FY 1995:
  - Complete TPS-59 system integration effort and initiate contractor's developmental tests;
  - Begin production of HAWK modifications;
  - Conduct Air Defense Communications Platform integration and testing;
  - Conduct Air Defense Communications Platform Test Readiness review.

2.7.3 *Launch Detection*

Improved launch detection will provide earlier targeting opportunities for active defense elements and earlier warning for passive defense. Counterforce strikes may also benefit from better launch point estimates. All of these improvements address shortcomings from Desert Storm. Three complementary programs which provide these improvements are the Air Force's TALON SHIELD program, the Navy's RADIANT IVORY program, and the Army-Navy Joint Tactical Ground Station (JTAGS) program.

TALON SHIELD is a BMDO sponsored data fusion program that processes multi-sensor Defense Support Platform (DSP) and classified sensor data at a central location at Falcon AFB, Colorado. RADIANT IVORY processes classified data from a unique sensor and provides the data to TALON SHIELD for fusion with other products. The JTAGS program is building a tactical mobile stereo DSP ground station for use in theater to provide up to trinocular processing of DSP sensor data. This program will ruggedize hardware and software developed under the BMDO sponsored Tactical Surveillance Demonstration (TSD) and TALON SHIELD programs and the Army/Navy sponsored Tactical Surveillance Demonstration Enhancement (TSDE) program. These hardware efforts will interface with Tactical and Related Applications (TRAP) and Tactical Information Broadcast Service (TIBS) networks in real time as well as other tactical data networks, providing a robust capability for users from all Services. The complementary capabilities of TALON SHIELD, RADIANT IVORY, and JTAGS are integrated within the USSPACECOM program for a tactical event system (TES). TES will meet the TMD requirements for launch detection and warning as the tactical processors mature from demonstrations to full operational capability.

Technical and operational testing continues throughout FY 1994. Significant TALON SHIELD tests include demonstrations of multiple satellite data fusion against cooperative launches and targets of opportunity, that occur during system checkout. Initial operational capability of the Attack and Launch Early Reporting to Theater (ALERT) system is scheduled for October 1994. The Army will conduct JTAGS EMD phase technical and operational tests during FY 1995.

- FY 1993 efforts resulted in the following accomplishments:
  - Completed TSD, RADIANT IVORY, and TALON SHIELD system demonstrations.

- Work planned for FY 1994:
  - Complete TALON SHIELD Developmental tests and begin Air Force operations;
  - Demonstrate improved netted sensor data processing at key TMD nodes;
  - TSD/TSDE continue to support the USSPACECOM Tactical Event System implementation plan and CINC TMD experiments.

- Work planned for FY 1995:
  - Achieve ALERT initial operational capability;
  - Continue to design and demonstrate TALON SHIELD capabilities;
  - Produce and conduct developmental/operational testing of two JTAGS engineering and manufacturing development units.

2.7.4 Sensor Cueing

Sensor cueing enhances target detection by fire control radar systems such as PATRIOT's AN/MPQ-53. Sensor cueing reduces radar loading for TBM detection and tracking by decreasing the radar's search volume. It extends the target acquisition range of fire control radar systems, precluding the radar as the limiting factor in defended area footprints. This increase in range is particularly important in non-benign environments, i.e., multi-target, Electronic Countermeasures (ECM), and inclement weather. Additionally, improved beam scheduling provides target acquisition in non-benign environments while reducing the system's vulnerability to saturation raids and to anti-radiation missiles.

Sensor cueing efforts include tactical cueing and netting demonstrations, for example, TMD weapons systems such as PATRIOT or THAAD cued by tactical systems and sensors such as JTAGS, SPY-1, or TPS-59. Other sensor efforts include tactical processing and application of space sensor data in the TALON SHIELD program and airborne sensor technology development.

The Extended Airborne Global Launch Evaluator (EAGLE) Program will provide the capability to acquire and track theater ballistic missiles during the late boost and midcourse phase. The program will develop a passive Infrared Search and Track (IRST) system and an active laser ranging system and field them on existing Air Force and Navy surveillance aircraft. On board processors will compute launch point estimates, impact point prediction, and threat position and velocity messages for transmission via a joint data link to command and control and fire control centers. The EAGLE Program will enter demonstration/validation in FY 1995 with a prototype flying in FY 1996.

- FY 1993 sensor cueing efforts resulted in the following accomplishments:
  - Developed and tested PATRIOT cueing software (engineering development);

- Demonstrated new long-range waveform during TMD Countermeasures Mitigation Program-1 (TCMP-1);
- Completed planning for PATRIOT/TPS-59/JTAGS cueing demonstration.

- Work completed and planned for FY 1994:
  - Conducted a developmental cueing demonstration between TPS-59/PATRIOT and JTAGS/PATRIOT with a TBM target at White Sands Missile Range; TPS-59 cued PATRIOT to a single beam acquisition; JTAGS cued PATRIOT repeatedly including some single beam acquisitions;
  - Begin planning for a Tri-Service tactical cueing capability;
  - Publish TPS-59/PATRIOT and JTAGS/PATRIOT interface control documents.

- Work planned for FY 1995:
  - Demonstrate tactical cueing of PATRIOT from TPS-59 and JTAGS;
  - Cue AEGIS from national assets via TRAP/TRE;
  - Begin EAGLE Program Demonstration/Validation.

2.7.5 CINCs TMD Experiments Program

The CINCs TMD Experiments Program is improving current TMD command, control, and communications capabilities in the field. This program is designed to increase the understanding of TMD capabilities, to develop and refine tactics, and to implement TMD force operations as developed by the theater CINCs. The CINCs TMD Experiments Program helps the CINC perform TMD missions by subsidizing the cost of including realistic TMD activity into existing exercises, providing expertise to the CINC in exercise planning and communications connectivity, and bringing new ideas and capabilities to the field during exercises. The exchange of information between the users and developers has fostered great interest among the CINCs during the past two years. The result has been substantial increases in current and near term TMD capabilities without the addition of a new weapon system.

Each year participating CINCs establish TMD experiment goals and objectives for the succeeding two years. During workshops, representatives from the doctrine and technology communities present concepts for improving current TMD capabilities. These concepts are prioritized and a cost analysis is performed. Once the budget for the program is finalized, CINC objectives are funded according to assigned priorities. Experiments are then planned and executed within the prioritized funding.

- FY 1993 efforts resulted in the following accomplishments:
  - Demonstrated the effectiveness of the Air Defense Systems Integrator (ADSI) to

establish interoperable communications between Army, Navy, and Air Force systems. ADSI was used in FY 1993 to establish a theater wide, common air picture by the European Command (EUCOM) in OPTIC NEEDLE I and by U.S. Forces Korea (USFK) in ORNATE IMPACT I. ADSI was also used by an AEGIS cruiser to cue a PATRIOT battalion during OPTIC NEEDLE I.

- Demonstrated the utility and effectiveness of employing a Scud/TMD cell, composed of dedicated personnel and equipment, within the theaters. USFK established a "Scud" cell, during ORNATE IMPACT I; EUCOM established a TMD cell during OPTIC NEEDLE I.
- Demonstrated the utility of employing the Joint Tactical Ground Station (JTAGS) during ORNATE IMPACT I and OPTIC NEEDLE I. JTAGS gives the theater the capability to process and visually monitor Defense Satellite Program (DSP) satellite information, which provides early launch warning.
- Demonstrated the capability to provide TALON SHIELD information to the theater during ORNATE IMPACT I and OPTIC NEEDLE I. In both cases, the communications connectivity was established and maintained; TALON SHIELD information was received and processed in the theater.
- Demonstrated the capability of EUCOM's TMD cell to process TMD intelligence and forward targeting information to field artillery systems to enable rapid engagement of high priority targets.
- Supported Central Command (CENTCOM) publication of a tactics, techniques, and procedures manual.
- Enhanced combat effectiveness during FY 1993 through Pacific Command (PACOM) and EUCOM refinements to their TMD planning processes and communications procedures. These were practiced during exercises, resulting in better trained planners and operators.

- Work planned for FY 1994:
  - PACOM will conduct ORNATE IMPACT II, a Command Post Exercise (CPX) with a TMD overlay in USFK. PACOM's intent is to improve the effectiveness of systems established during OPTIC NEEDLE I.
  - EUCOM will conduct OPTIC NEEDLE II, a Field Training Exercise (FTX) conducted in Europe. EUCOM's intent is to enhance its ability to disseminate early warning, intelligence, and imagery, and improve the interoperability between Army and Navy radars.
  - CENTCOM will participate in ROVING SANDS 94, a CPX/FTX conducted in Continential United States (CONUS). CENTCOM's intent is to validate its new tactics, techniques, and procedures manual, and to experiment with incremental introduction of TMD capability in an undeveloped theater.
  - Atlantic Command (ACOM) will participate in the program for the first time using

a predeployment exercise with Joint Task Force 95. ACOM wants to explore new means of information exchange between PATRIOT and AEGIS, as well as test procedures for processing DSP information. ACOM will also experiment with new techniques for passing target information to the cockpit for attack aircraft.

- Work Planned for FY 1995:
  - EUCOM will conduct quarterly TMD exercises involving component and regional commands;
  - PACOM will continue TMD experiments by USFK/CFC, expand TMD efforts by U.S. Forces Japan, and integrate TMD into its PACOM Joint Task Force exercises;
  - CENTCOM will integrate TMD into command post and field training exercises.

2.7.6 TMD Current Systems Improvements Program

A formal TMD Current Systems Improvements Program is being established to continuously identify and recommend modifications to existing systems to improve their TMD capability. This program provides BMDO, Service acquisition organizations, and the users, through their Services, the opportunity to identify and recommend materiel improvements to their warfighting capability which can be implemented and fielded within the next four years. The TMD Current Systems Improvements Program will identify, select, and sponsor those improvements that are consistent with the program's objective. A TMD Current Systems Improvements Working Group and Flag Officer's Steering Committee will be established to provide recommendations to BMDO for further action. Oversight and review will be maintained throughout the implementation of an improvement to ensure satisfactory cost and schedule control.

2.8 Core Programs

The three core programs are: (1) PATRIOT Advanced Capability-3 (PAC-3), which adds a new, highly lethal hit-to-kill interceptor and improves radar capability of the PATRIOT system; (2) THAAD and the TMD-GBR, which provides a capability against longer range threats, decreases leakage by adding an upper tier, provides the improved lethality of hit-to-kill, provides wide area protection of highly dispersed assets, and has improved deployability; and (3) Sea Based Area Theater Ballistic Missile Defense (TBMD), which aids deployability by providing global presence and gives the capability to protect insertion forces. Figure 2-7 shows the core programs inserted into the TMD active defense framework. The following sections discuss the status of the core programs.

2.8.1 PATRIOT Advanced Capability-3 (PAC-3)

The PAC-3 program, which will improve the current PAC-2 system through a series of upgrades to the PATRIOT radar and the selection of a new missile, will satisfy the PAC-3 requirement to increase system battlespace and lethality capabilities. The planned radar enhancements will increase detection range, provide positive target identification, improve the engagement of targets with reduced radar signatures, increase target handling capability, increase firepower, and enhance survivability.

Figure 2-7. TMD Active Defense Framework Core Programs

	Land	Sea	Air
Upper	THAAD System (FUE FY 01; UOES FY 97)		
Lower	PATRIOT (FY 98)	AEGIS With SM-2 Block IVA (FUE FY 99; UOES FY 97)	
	DSP	JTAGS TALON SHIELD RADIANT IVORY	TPS-59

BM/C 3

☐ BUR Core Program*   ☐ Enhanced Capability

* Emphasizes Upgrades To Existing / Fielded Systems

Combination Gives CINC Flexible Deployment / Employment Options

Two missiles were considered for the PAC-3 program: the Multimode Missile (MMM) and the Extended Range Interceptor (ERINT). In the second quarter of FY 1994 the Army selected the ERINT missile. ERINT is a hit-to-kill interceptor that provides active defense against TBMs and air breathing threats. It uses an on board active Ka-band seeker, aerodynamic control vanes, and impulse attitude control thrusters to provide the rapid maneuvering necessary for a hit-to-kill intercept. The ERINT missile is designed and built to be completely compatible with the PATRIOT system. Hit-to-kill technology, as opposed to blast fragmentation, will increase lethality against mass destruction warheads.

An independent review by OSD of the ERINT selection as a precursor to the PAC-3 Defense Acquisition Board (DAB) supported the ARMY decision. The DAB reviewed the ERINT selection and approved the PAC-3 program with ERINT to enter into the Engineering and Manufacturing Development (EMD) phase.

The Dem/Val flight test program consists of two Controlled Test Flights (CTF) and six Guided Test Flights (GTF) against surrogate tactical ballistic missiles, air breathing threats, and maneuvering targets. To date, both CTFs and three of the six GTFs have been conducted. The ERINT missile spectacularly demonstrated its hit-to-kill capability during its last two test flights, each conducted against a ballistic tactical target vehicle. In one case, ERINT neutralized all the canisters in a simulated chemical submunition warhead. In the second case, ERINT completely destroyed a target vehicle carrying a simulated bulk chemical warhead.

The ERINT missile will undergo Developmental Test and Evaluation (DT&E) and missile flight tests using Post Deployment Build PAC-3 missile flight test software. DT&E will verify the engineering and manufacturing development process and determine readiness of the missile to enter operational testing. DT&E will occur between the first quarter of FY 1995 and the first quarter of FY 1998.

Operational Test And Evaluation (OT&E) will verify the operational effectiveness and suitability of the PAC-3 system to meet operational performance requirements described in the operational requirements document.

- FY 1993 efforts resulted in the following accomplishments:
  - Continued PAC-3 missile review process and initiate EMD program;
  - Initiated Phase III radar integration testing;
  - Continued remote launch development;
  - Completed two test flights of the multimode seeker;
  - Continued to execute the PATRIOT-ERINT integration program;
  - Completed one ERINT guidance test flight.

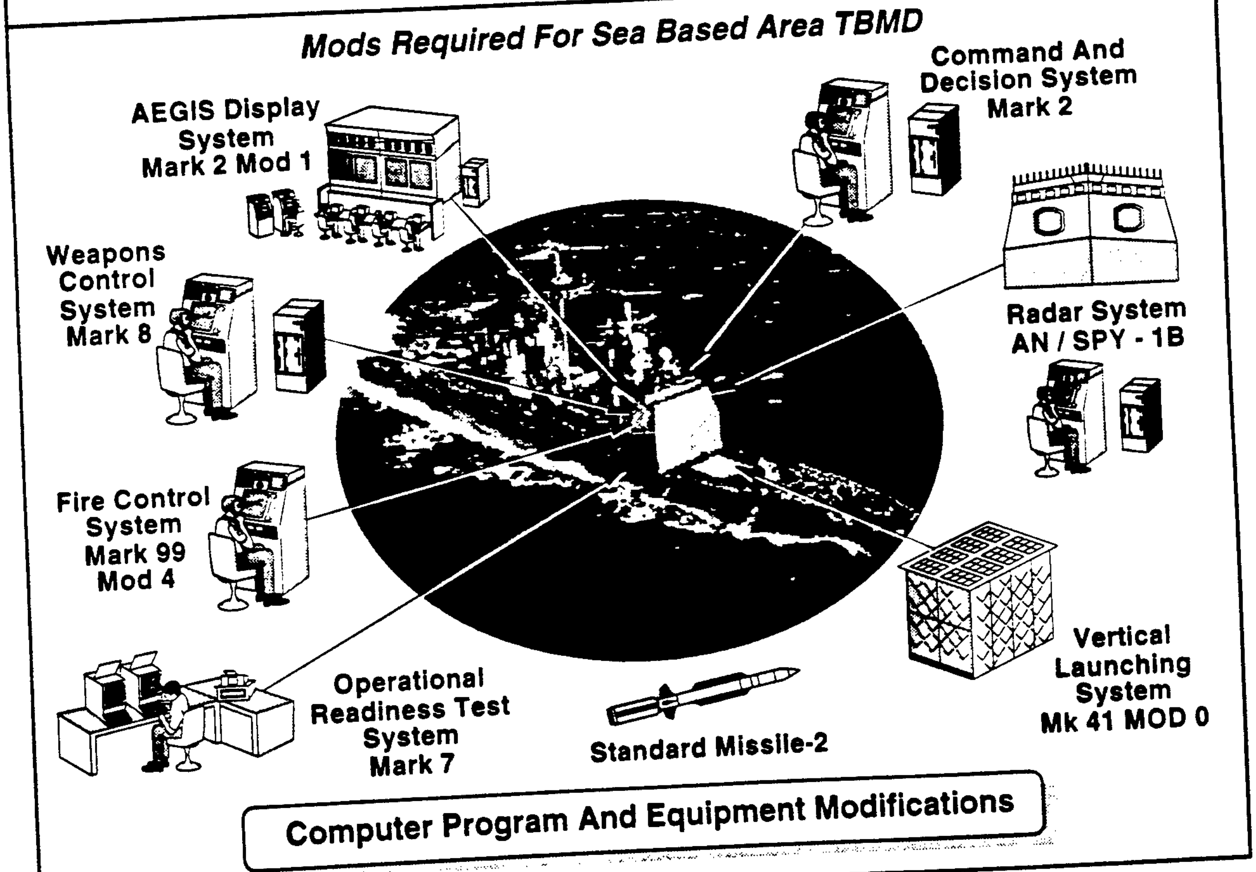
- Work planned for FY 1994:
  - Complete PAC-3 missile review process;
  - Complete multimode missile improved warhead development and test;
  - Complete radar enhancements Phase III subsystem testing and integration;
  - Continue remote launch development;
  - Complete the PATRIOT-ERINT integration program;
  - Initiate system integration and testing;
  - Complete ERINT Dem/Val flight test program;
  - Initiate hardware/software developmental testing.

- Work planned for FY 1995:
  - Conduct Phase III radar production decision review;
  - Complete remote launch integration and testing;
  - Continue system integration and testing;
  - Continue hardware/software developmental testing.

2.8.2 Sea Based Area TBMD

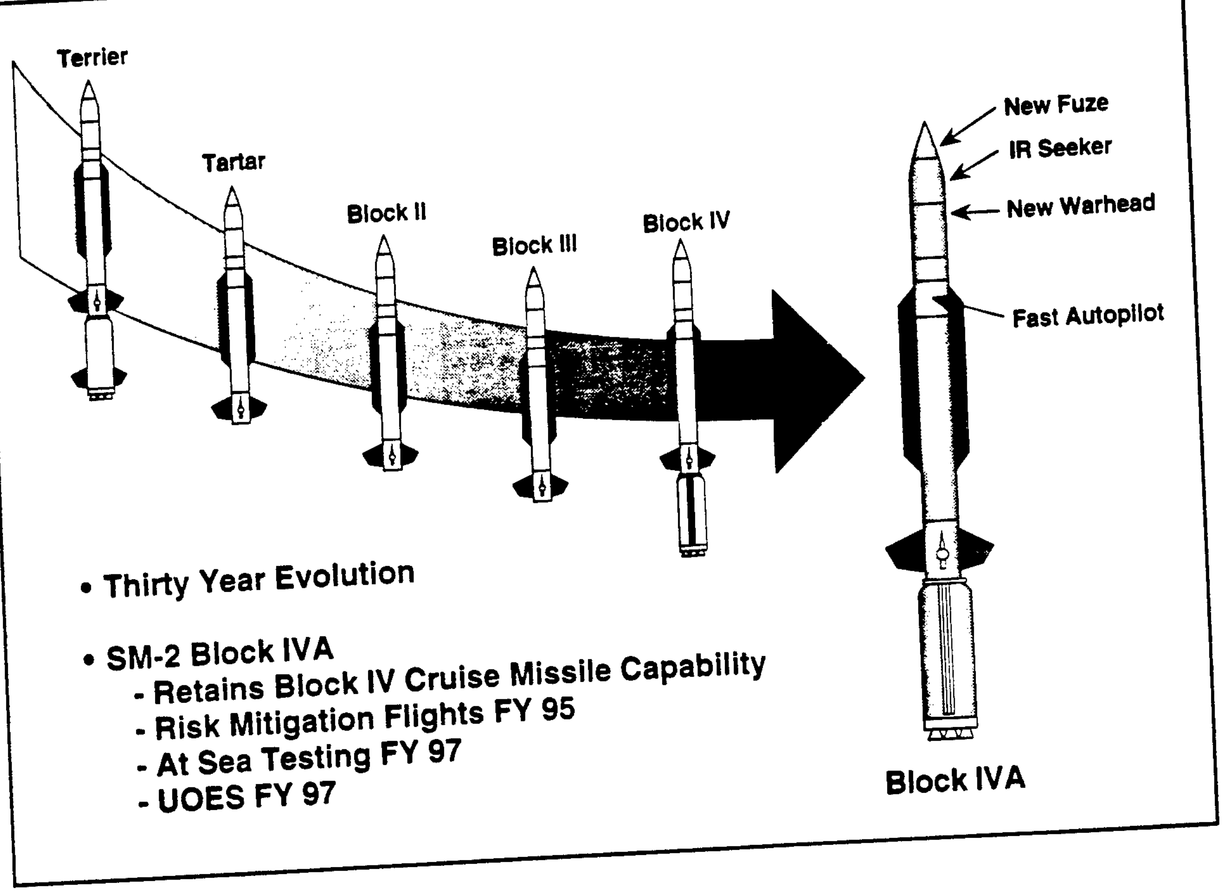
The goal of this Navy effort is to provide a sea based area defense capability building on the existing AEGIS system, shown in Figure 2-8. This effort focuses on modifying the AEGIS combat system to enable TBM detection, tracking, and engagement by a modified Standard Missile SM-2 Block IV. The SPY-1 radar computer programs and equipment will be modified to allow search at higher elevations and longer ranges in order to detect TBMs and to maintain track on the ballistic targets. The weapon control system will predict intercept points and engagement boundaries for ballistic targets, initialize missiles, conduct firings, and provide uplink commands as the missile flies to intercept the TBM. AEGIS displays and the on board command and decision system computer programs and equipment will be modified to display TBM tracks and engagements and to interface with other elements of the combat system as well as with off ship sensors (e.g., DSP).

Figure 2-8. AEGIS Weapon System Mark 7



The SM-2 Block IV, currently in engineering development, is the basis for the initial sea based TMD capability that focuses on the more numerous, shorter range, lower apogee threats. As noted in Figure 2-9, BMDO is considering changes to the baseline SM-2 Block IV warhead, seeker, and fuze to improve intercept performance against ballistic missiles within the atmosphere. Warhead modifications will capitalize on engineering analysis and design efforts already completed for the PATRIOT missile. An adjunct infrared (IR) seeker will be used to reduce miss distance. The fuze will be improved to ensure proper performance in the high closing rate missile-to-missile encounters. The modified SM-2 Block IV (designated SM-2 Block IVA) is being designed to retain capability against aircraft and antiship cruise missiles while providing the maximum possible capability against theater ballistic missiles.

Figure 2-9. Standard Missile Evolution



In addition to the early risk reduction test missiles planned to support testing in 1995 through 1997, 35 missiles will be procured for use with the AEGIS User Operational Evaluation System (UOES) to provide a mid decade contingency. Low Rate Initial Production (LRIP) beginning in 1997 will make an additional 55 missiles available in 1999, and 90 missiles in 2000.

The test and evaluation (T&E) effort for the sea based area TBMD program is an outgrowth of almost 20 years of computer program development and management, missile development, and AEGIS weapon system engineering. The T&E program includes early missile hardware integration and flight test, IR seeker wind tunnel and sled testing, warhead development with lessons learned from PATRIOT, early at sea testing of prototypical computer programs, and extensive land based development of AEGIS weapon system computer programs and equipments at the Combat System Engineering Development Site in Moorestown, New Jersey.

Early flight tests are planned starting in FY 1995, first at the White Sands Missile Range, and then on an operational AEGIS ship with supporting computer programs. Additional at sea testing will include multiple engagement scenarios, electronic countermeasures (ECM), and other measures designed to rigorously test the robustness of the system. The first fleet unit will receive operational SM-2 Block IVA interceptors and AEGIS TBMD tactical computer programs in 1999.

- FY 1993 efforts resulted in the following accomplishments:
  - Issued Sea Based TBMD Mission Need Statement and AEGIS and SM-2 Block IVA Operational Requirements Documents;
  - Commenced design and evaluation of necessary AEGIS combat system modifications;
  - Delivered preliminary SPY radar tracking computer program modifications to support the collection of ballistic missile tracking data at sea;
  - Completed concept definition of SM-2 Block IV modifications required to provide TBM intercept capability and initiated risk mitigation efforts;
  - Demonstrated developmental computer programs used to detect and track TBMs at extremely long ranges.

- Work planned for FY 1994:
  - Continue design of AEGIS combat system modifications;
  - Continue development/design of SM-2 Block IV modifications to provide for TBM intercept capability;
  - Continue risk mitigation efforts;
  - Demonstrate AEGIS communication with PATRIOT system in consonance with the JADO/JEZ event;
  - Develop subsystems of the SM-2 Block IVA to support risk reduction flight tests in FY 1995;
  - Continue computer programs and equipment development to accept stereo DSP and cue AEGIS to increase track acquisition range against a TBM.

- Work planned for FY 1995:
  - Complete design of initial AEGIS combat system computer program and equipment modifications to enable TBMD detection, tracking and weapon processing to support an SM-2 missile with TBMD capability;

- Conduct warhead lethality arena tests;
- Conduct land based and sea based experiments to demonstrate automated acceptance of long-range (off ship) cueing and SPY radar acquisition;
- Initiate procurement of developmental SM-2 Block IVA missiles to support an FY 1997 UOES and planned flight tests;
- Commence risk reduction flight tests at White Sands Missile Range to resolve issues of thermal blur, IR seeker performance, IR cover survivability, and model validation.

2.8.3 THAAD and TMD-GBR

The THAAD system, shown in Figure 2-10, consists of two separate but closely associated Army programs: the THAAD weapon system and the Theater Missile Defense-Ground Based Radar (TMD-GBR) surveillance and fire control radar system. The THAAD system comprises the upper tier of a two tiered, ground based defense against TBMs. This system will provide broad surveillance and a large intercept envelope to defeat missile threats directed against wide areas, dispersed assets, and strategic assets such as population centers and industrial facilities. THAAD will engage at high altitudes to minimize damage caused by debris and chemical/nuclear munitions. The combination of high altitude and long-range intercept capability may provide multiple engagement (shoot-look-shoot) opportunities. The system will be interoperable with other U.S. and NATO air defense systems and is capable of receiving cueing data from U.S. space based sensors.

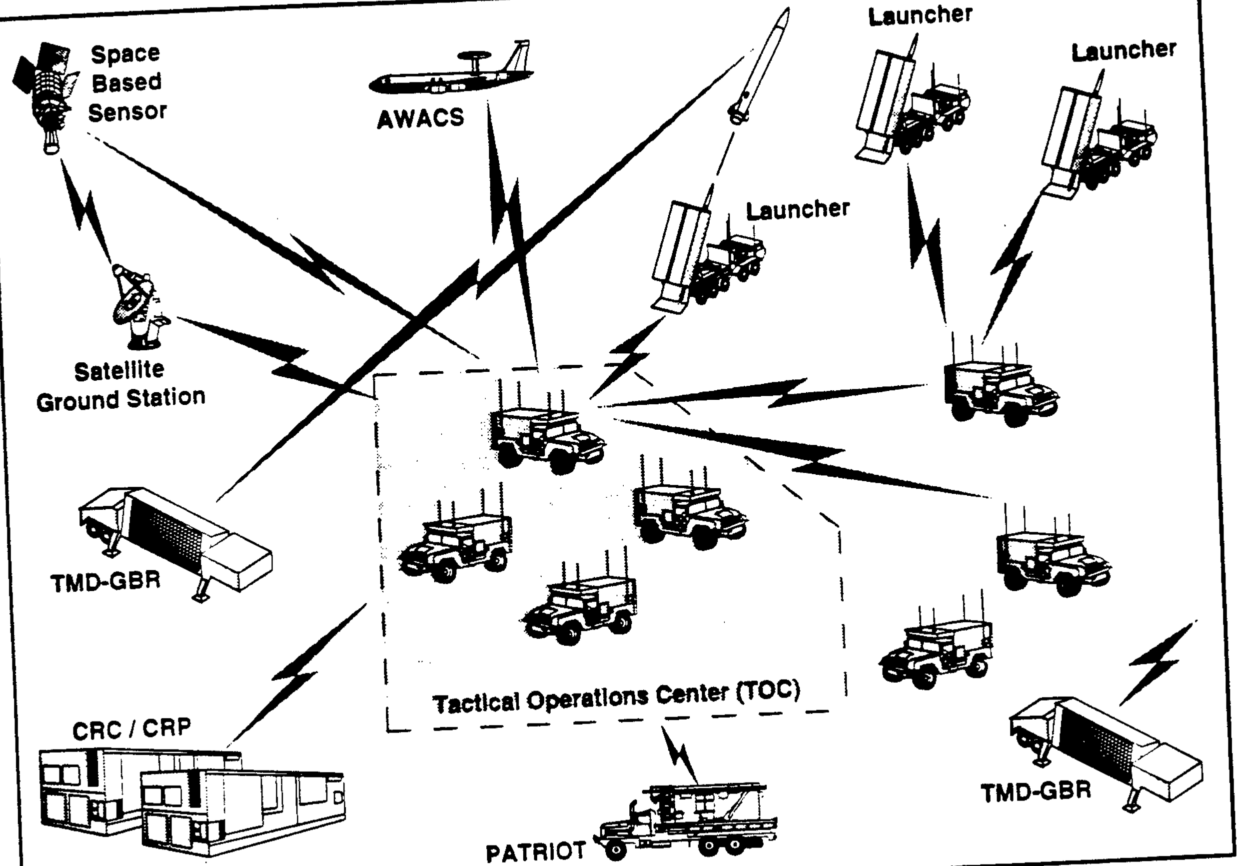
The THAAD weapon system includes missiles, launchers, C^3I units, and ground support equipment. The system will be C-130/C-141 aircraft transportable and will use existing standard government power generation equipment. The THAAD C^3I units will be compatible with the Air Defense Tactical Operations Center (ADTOC) to enable communication with higher and lower echelons. Additionally, the THAAD C^3I segment will be able to accept cueing data from a variety of external sensors.

The THAAD missile is a single stage, solid fuel missile. The missile employs thrust vector technology and a divert and attitude control system. Predicted intercept point and guidance presets are provided by the TMD-GBR to the missile prior to launch. The THAAD missile is capable of receiving in-flight updates including a target object map for target designation. Terminal guidance data is provided by an infrared seeker looking through a side mounted, uncooled window. The seeker window is protected by a shroud which separates prior to terminal homing. The THAAD missile kill vehicle exhibits enhanced lethality by destroying incoming warheads utilizing kinetic energy impact (hit-to-kill). It is capable of both endo- and exoatmospheric intercepts.

The THAAD launcher contains a missile round pallet mounted on a U.S. Army common Palletized Loading System truck. Primary power to the launcher is supplied by lead acid batteries that are automatically recharged by a quiet tactical generator. Launch position is determined by the Global Positioning System and the launch azimuth by a Direction Reference Unit.

The C^3I system is designed to control automated TBM acquisition and identification, track data

Figure 2-10. THAAD / TMD-GBR System



processing and dissemination, weapon assignment, engagement monitoring, and sensor operation. The C³I equipment is configured into the Standard Integrated Command Post Shelter mounted on a high mobility, multipurpose wheeled vehicle. The command and control netted, distributed, and replicated architecture allows for maximum flexibility to operate at the battalion or battery level. The use of common hardware and software, and standard communication protocols also allow cueing from external sources and cueing down to lower tier systems.

The TMD-GBR is the THAAD primary sensor and uses state-of-the-art radar technology and provides theater wide surveillance, discrimination, and fire control for the weapon system. It consists of five major elements: a mobile, single faced, phased array radar utilizing solid-state transmit/receive modules and separate power generation, system cooling, electronic equipment control, and operations control units. The radar operates in the X-band and provides early warning of threat TBM launches by detecting and acquiring targets at very long ranges using autonomous horizon fence and volume search acquisition modes. The radar performs classification and discrimination to categorize the target type and identify the reentry vehicle. The radar maintains track on the target and provides in-flight updates to the missile prior to intercept. The TMD-GBR provides the critical data to allow the THAAD system to perform kill assessment which supports the decision to commit additional interceptors or to cue lower tier systems such as PATRIOT and the AEGIS weapon system.

The Dem/Val phase of the THAAD program includes a comprehensive, integrated, ground and flight test schedule to demonstrate sufficient design maturity to enter EMD and to verify that the deployable prototype UOES has operational capability. The test program initially focuses on computer simulation, early breadboard and brass board hardware, and piece-part and component developmental testing. This testing evolves into subsystem, system environment, and functional demonstrations, leading into ground and flight system interface and integration tests.

The THAAD test program will ensure that all critical design and performance issues are resolved early and that the THAAD system will meet all operational and functional requirements. The centerpiece of the THAAD test program will be the flight test program at White Sands Missile Range. The first flight is scheduled for fall 1994. Missile flight tests will be followed by system tests to incrementally demonstrate increased performance capability by integrated missile, launcher, radar, and C^3I systems.

The TMD-GBR Dem/Val test program consists of two phases. The first phase consists of contractor in-plant testing and integration. The second phase consists of government integration and flight test verification activities at White Sands Missile Range.

In addition to the Dem/Val radar unit, two TMD-GBR UOES units will be developed to support the THAAD UOES. These UOES versions of the TMD-GBR will be deployable and available to support THAAD interceptor testing beginning in October 1995.

- FY 1993 efforts resulted in the following accomplishments:
  - Conducted initial design review on 20-21 January 1993;
  - Demonstrated missile design in wind tunnel tests;
  - Completed nuclear hardening study;
  - Complete AEGIS/VLS compatibility study;
  - Conducted booster and shroud separation testing;
  - Began Hardware-In-The-Loop (HWIL) testing;
  - Completed TMD-GBR Dem/Val preliminary and critical design reviews;
  - Conducted TMD-GBR UOES design reviews;
  - Completed TMD-GBR solid-state demonstration array preliminary design review;
  - Initiated fabrication of TMD-GBR Dem/Val radar.

- Work planned for FY 1994:
  - Continue subcomponent testing such as seeker, booster, etc.;
  - Conduct final design review;
  - Continue HWIL testing;

- Continue lethality testing;
- Begin TMD-GBR test bed integration;
- Continue TMD-GBR Dem/Val radar fabrication and perform contractor in-plant testing;
- Begin construction of WSMR facilities;
- Complete TMD-GBR UOES design reviews;
- Begin TMD-GBR UOES fabrication;
- Continue TMD-GBR solid state demonstration array risk reduction program.

- Work planned for FY 1995:
  - Begin THAAD missile flight test program at White Sands Missile Range;
  - Continue risk mitigation efforts;
  - Complete fabrication and in-plant testing of TMD-GBR Dem/Val and UOES radars;
  - Begin integration of TMD-GBR into the THAAD System at White Sands Missile Range;
  - Begin THAAD System testing with TMD-GBR launcher;
  - Continue TMD-GBR solid-state demonstration array risk reduction program.
  - Conduct Objective System Requirements Review (SRR).

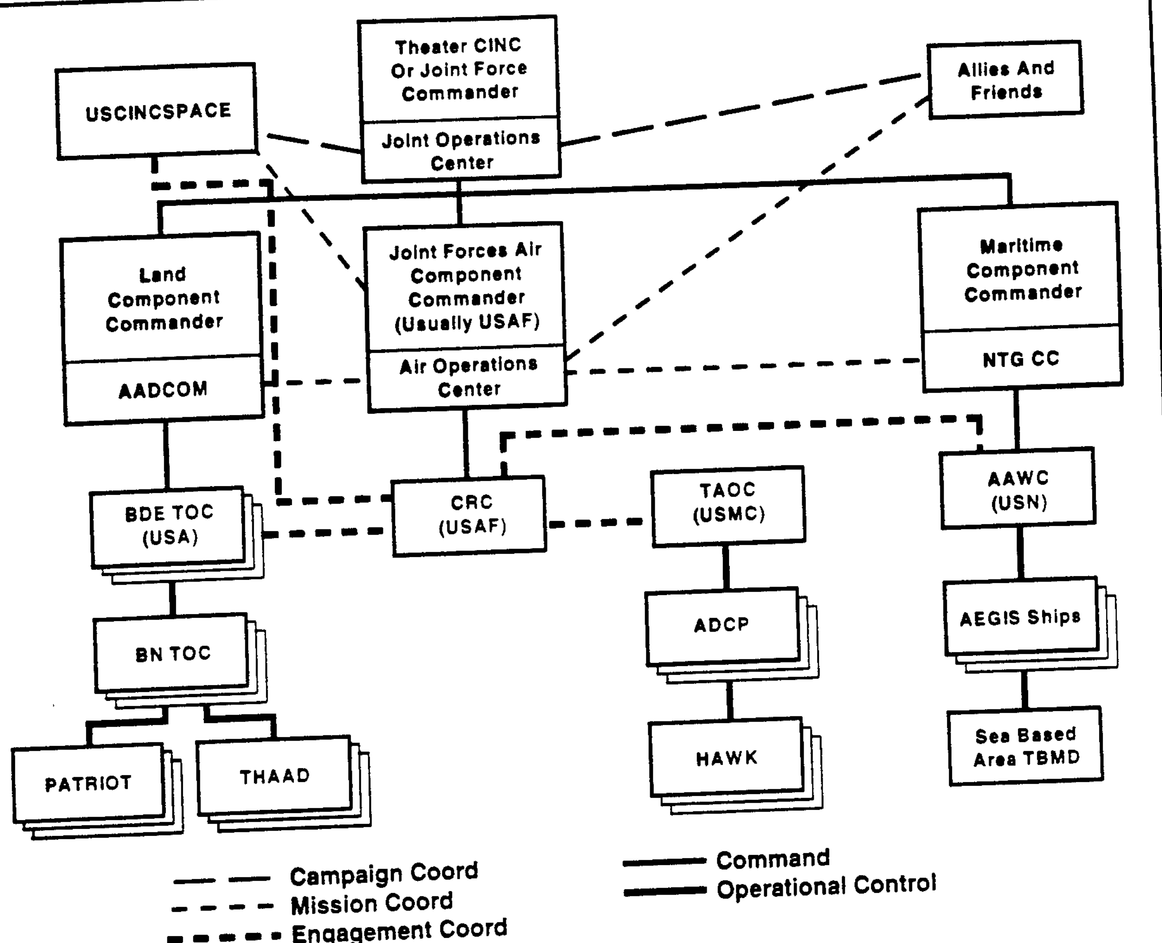
2.8.4 *Battle Management/Command, Control, Communications, and Intelligence (BM/C³I)*

Interoperability in BM/C³I is essential for joint TMD operations. Accordingly, BMDO is taking an aggressive lead to establish an architecture that all the Services can build upon and is actively pursuing three thrusts to ensure an effective and joint BM/C³I for TMD.

2.8.4.1 *C³I Architecture*

The C³I architecture for TMD consists of the command and control (C²) structure for theater air defense; the communications linking TMD C², weapons, and sensors; and the TMD interfaces to intelligence systems and other supporting capabilities. Figure 2-11 shows the TMD C² structure consistent with current doctrine. The rapid time frames associated with the execution of TMD require closely coordinated command and control for centralized planning and guidance with decentralized execution. To ensure optimized planning and guidance, BMDO is focusing on accomplishing the horizontal linkages among the theater command centers and operations centers, which could be deployed in various combinations over time from one theater or contingency to another.

Figure 2-11. TMD Command And Control Structure



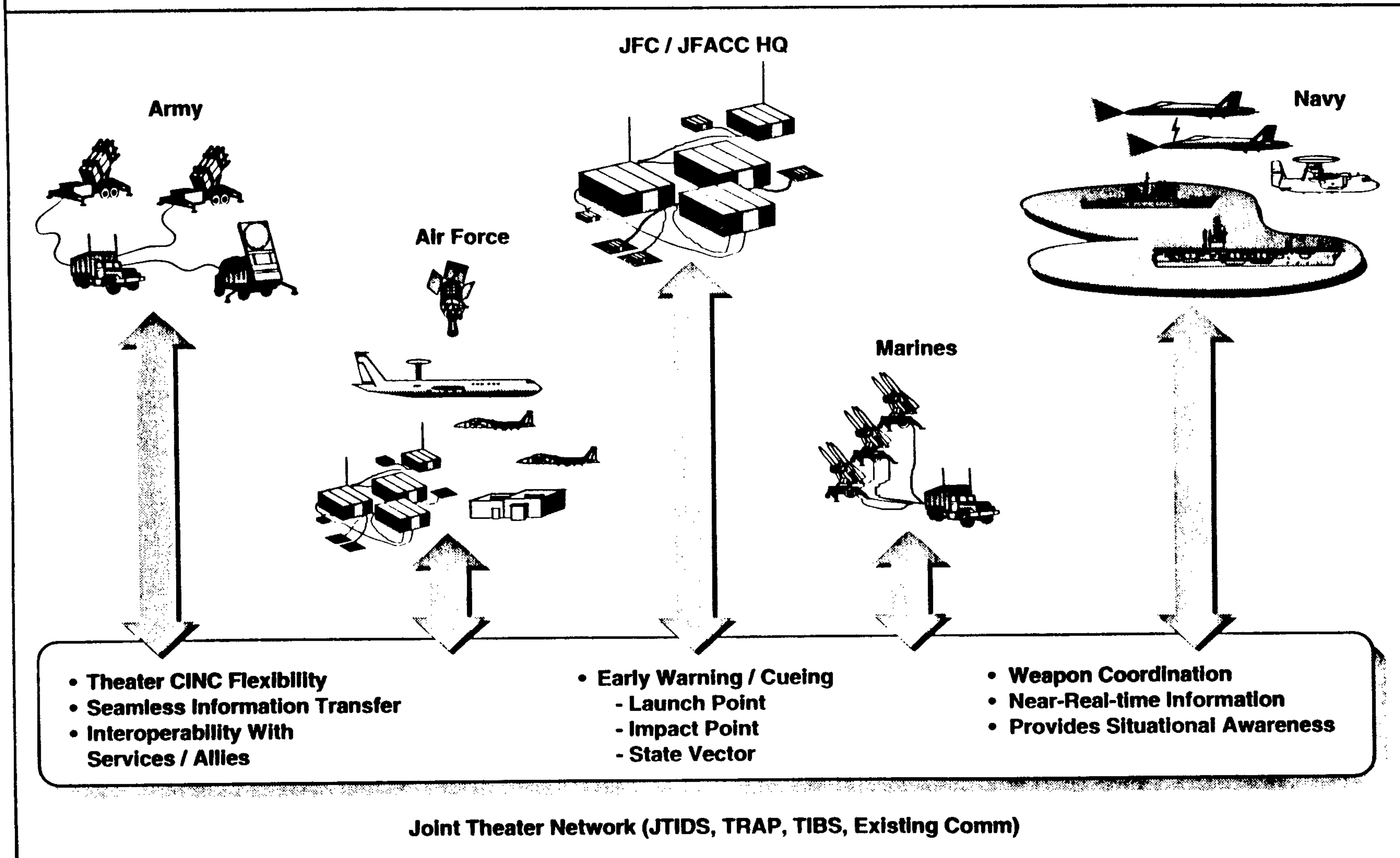
Communications for TMD are designed to make target and engagement information available in near real time to TMD elements at all levels. The functioning of the Joint Near-Real-time Data Net is shown in Figure 2-12. All Services will interoperate via this net, which will allow early cueing of sensors and greater opportunity for TBM engagements. This joint data distribution will result in more successful engagements and less leakage of hostile missiles through our defenses.

The intelligence portion of the architecture focuses on the TIBS and the TRAP. TIBS and TRAP are satellite broadcast systems which disseminate information from theater and national intelligence resources. TMD forces rely on TIBS and TRAP, in combination with the Joint Near-Real-time Data Net, for receipt of launch warning information produced by tactical processors of DSP data (e.g., JTAGS in the theater or TALON SHIELD in CONUS).

2.8.4.2 BM/C^{3}I Thrusts

BMDO has three major thrusts to the TMD BM/C^{3}I program.The first thrust establishes the links and means for in-theater dissemination of launch warning information from space based and intelligence systems external to TMD. As discussed in previous sections, improved capabilities for

Figure 2-12. Joint Near-Real-time Data Net



surveillance and launch warning in support of TMD have already been established through the exploitation of space based systems and development of tactical processing prototypes by BMDO and the Services. Success in this area was the initial thrust of the BM/C^{3}I program, providing early and responsive support to user commands from JTAGS and TALON SHIELD, and resulting in planned IOCs for the tactical processing systems in FY 1994 and FY 1995. BMDO continues its role in integrating the TIBS and TRAP with in-theater communications and operational systems.

The second thrust of the BM/C^{3}I program focuses on the communication of information via the Joint Near-Real-time Data Net. In conjunction with the Joint Interoperability Engineering Organization (JIEO), BMDO led a subpanel established under the Joint Multi-TADIL Standards Working Group to define those joint message formats associated with TMD that must be utilized by all the Services in their TMD role. This activity to define standards and interfaces resulted in agreement on common information needs as well as format for joint TMD messages. A TADIL-J interface change proposal was agreed to by all the Services and presented to the JIEO Configuration Control Board for approval. This will allow all acquisition activities under the other core programs to develop the appropriate software to integrate communications hardware with host platforms to ensure these systems can communicate with each other. BMDO continues to monitor and influence the Services' C^3 programs to ensure that funding and schedules support deployment of TMD weapons systems on agreed time lines. Joint Tactical Information Distribution System (JTIDS) capability, for example, will be available for THAAD UOES fielding.

The third thrust of the BM/C^{3}I program directs attention to the Service upgrades of C^2 centers. BMDO's central direction and support of hardware and software developments will produce an integrated C^2 capability for TMD. This thrust includes BMDO funded software integration, prototyping, and evaluation activities such as the Army Combined Arms Tactical Operations (CATO) and the Air Force Defense Systems Integrator (ADSI) which have been conducted in conjunction with field and command post exercises such as ROVING SANDS, Operations Concept Development, BLUE FLAG, and CINCs' TMD Experiments such as OPTIC NEEDLE. These exercises and war games raise specific issues in operational practices and procedures; and by providing essential insights for joint TMD concepts of operations, they allow BMDO to develop the C^{3}I needed for fully integrated TMD operations. BMDO will develop a TMD Information Architecture (IA) based on the methodology prescribed by the DoD core C^2 Model. This effort, as with the JTIDS joint message format effort, will define a common information structure upon which all the Services can build. BMDO will conduct the IA development, with the Air Force as the lead Service to serve as a management tool in ensuring that data flows, processing needs, and display items are commonly defined across Service C^2 programs. An additional benefit from building the information architecture is producing an engineering framework from which TMD can grow in the future, as needed, to help constitute the capability for a National Missile Defense (NMD). Finally, BMDO is emphasizing C^2 center developments in an open architecture with maximum use of commerical off-the-shelf software. C^2 information systems that typify this approach include the Navy's Joint Maritime Command Information System (JMCIS) and the Air Force's Contingency TACS Automated Planning System (CTAPS).

In a continuous effort to validate the C^{3}I architecture and to measure the progress of the three BM/C^{3}I thrusts, BMDO is responsible for testing of integrated BM/C^{3}I for TMD. This includes BMDO sponsored war games which will use the facilities of the National Test Facility and the

Advanced Research Center to assist in refining the information architecture through user interactions and quantifying performance parameters to be met by service programs. Additionally, BMDO will use end-to-end simulations, man-in-the-loop tests, and Hardware-In-The-Loop tests to validate BM/C³I requirements and determine that those requirements have been met. To meet the specific needs of TMD testing, systems integration tests will be conducted using the TMD System Exerciser (TMDSE) to simulate the operational environment and to drive each of the elements participating via Hardware-In-The-Loop. As a distributed test tool, the TMDSE can operate in a wholly simulated environment or in conjunction with live fire test events to demonstrate TMD system responsiveness and performance as an integrated whole. The proof-of-principle demonstration of the TMDSE will be concluded in FY 1994.

- FY 1993 efforts resulted in the following accomplishments:
  - Initiated TMD subgroup for TMD upgrades to TADIL J;
  - Produced a draft revised TADIL J interface change proposals;
  - Presented draft TADIL J interface change proposal to NATO Data Link Group;
  - Analyzed loading and availability of Joint TMD net;
  - Analyzed TMD C³I in support of NATO Research Study Group 16 using The Extended Air Defense Simulation (EADSIM);
  - Demonstrated Tactical Operations Center (TOC) prototype during ROVING SANDS exercise;
  - Initiated Tactical Processing Working Group;
  - Upgrades to the modular control equipment for the Air Operations Center.

- Work planned for FY 1994:
  - Begin prototyping of Air Defense Command Post;
  - Demonstrate C² connectivity to national assets;
  - Demonstrate Operations Concept Demonstration II and C⁴I connectivity in ROVING SANDS 94 exercise;
  - Develop gateway concepts and conduct trade-offs;
  - Develop decision support aids for JFACC battle management;
  - Conduct surveillance data fusion study;
  - Obtain Configuration Control Board approval of TMD message standard;
  - Initiate and complete Tactical Information Broadcast Service (TIBS) correlation algorithm;
  - Apply open architecture approaches to TMD System Exerciser interfaces and conduct proof-of-principle test;

- Obtain NATO approval of TMD message standard.
- Develop operational interfaces among TRAP/TIBS/Central Tactical Processing Program (CTPP) message sets;
- Conduct TMD wargame.

- Work planned for FY 1995:
  - Integrate prototype capabilities into Air Defense TOC weapon systems;
  - Develop TMD intelligence support template;
  - Develop implementation plan for TMD messages on Air Force, Army, and Navy platforms;
  - Complete AOC automation under CTAPS;
  - Develop TMD message software;
  - Continue TMD wargame.

2.8.5 Cost Effectiveness

The method by which cost and effectiveness are evaluated is the cost and operational effectiveness analysis (COEA). A COEA is required at each acquisition milestone. Two of the three core programs have had a formal acquisition review. THAAD had a Milestone I review, including a COEA, in FY 1992 as part of the Upper Tier Theater Missile Defense System (UTTMDS). PAC-3 is in the midst of a Milestone IV review and a COEA has been completed. Sea Based Area TBMD is scheduled for a milestone review in FY 1996. A COEA will be completed to support this review or earlier if appropriate. The next two subsections summarize the COEAs for PAC-3 and THAAD.

2.8.5.1 PAC-3

The PAC-3 COEA considered three missile alternatives. The baseline was PAC-2 and the PAC-3 alternatives were the Multimode Missile (MMM) and the Extended Range Interceptor (ERINT). The missiles were evaluated singularly and in combination. For each alternative, a 20 year life cycle cost estimate for the total system and by subsystem (sensor, BM/C^{3}I, launcher, and missile) was provided for the following categories: research, development, test, and evaluation; procurement; military construction; operation and maintenance; military personnel; and the total.

Four primary analytical techniques were used. To address lethality issues, two non-scenario specific methods were employed: intercept analysis and missile area of influence. To address other issues, force-on-force effectiveness modeling was used including sensitivity analysis of key input parameters and the Force Effectiveness Model to evaluate excursions. The scenarios used are representative of likely situations for PATRIOT employment and include a Northeast Asia scenario and a Southwest Asia scenario. Threat missiles employing maneuver and penetration aids and chemical submunitions are incorporated.

- Some of the key points in the PAC-3 COEA were:
  - There are no significant cost differences between the MMM and ERINT;
  - Both the MMM and ERINT meet applicable Operational Requirement Document requirements and appear operationally efficient;
  - The MMM provides greater battlespace;
  - The ERINT provides greater firepower and greater lethality against TBMs particularly those with mass destruction warheads.

2.8.5.2 THAAD

The Upper Tier Theater Missile Defense System (UTTMDS) COEA considered five alternatives. The five alternatives were PAC-3, THAAD, Hypervelocity Gun, AEGIS/SM-2 Block IV, and the Israeli Arrow. For each alternative, an equal effectiveness analysis was conducted that determined the dollars, the manpower, and the airlift required.

Three scenarios were included in the analysis: Southwest Asia, Northeast Asia, and European Central. In addition to evaluating the five programs, two excursions were conducted: space based cueing and sea based interceptors.

- Some of the key points are:
  - Only THAAD satisfies all the requirements from the UTTMDS Operational Requirements Document;
  - THAAD is the most cost effective alternative.

On January 28, 1992 the Defense Acquisition Board approved Milestone I for THAAD.

2.8.6 Life Cycle Costs

The program life cycle cost estimates for the TMD core elements are summarized in Figure 2-13. The operations and support estimates extend 10 years beyond full operational capability. There is insufficient technical design and schedule information to provide life cycle costs for follow-on elements.

2.8.7 Units Costs and Production Rates

Figure 2-14 summarizes the units costs and production rate data for PAC-3, THAAD, and SM-2 Block IVA missiles, and the TMD-GBR radar for each year of procurement.

Figure 2-13. Core Programs Life Cycle Cost Estimates - Millions Of Then Year Dollars

Core Programs	PAC - 3	THAAD System		Sea Based Area TBMD
	ERINT	THAAD	TMD - GBR	AEGIS With SM-2 Block IVA
Demonstration And Validation	928.4	1,883.3	763.8	884.2
Engineering And Manufacturing Development	643.5	1,580.3	621.5	296.9
Production	2,680.9	4,803.9	2,344.8	3,665.8*
Acquisition Cost	4,252.8	8,267.5	3,730.1	4,846.9
Operations And Support**	103.8	2,540.1	2,437.7	Not Available
Life Cycle Cost	4,356.6	10,807.6	6,167.8	Not Available

* Production Jointly Funded By BMDO And Navy. Estimate Reflects BMDO Budget Only
** Includes Operations And Maintenance And Personnel Cost

2.9 Advanced Concepts

The core programs will provide a significant TMD capability consisting of lower and upper tier land based defense and lower tier sea based defense. The advanced concepts are those potential programs that complement the core programs by providing a highly mobile land based defense to protect mobile forces, a sea based theater wide defense against the long-range TBM threat, and an airborne capability for boost phase intercept. Sea Based Theater Wide defense was recommended for funding as a major acquisition program in the Bottom-Up Review. However, subsequent funding reductions changed the program from a funded major acquisition to a candidate concept for a new start in FY 1998, along with Boost Phase Intercept and Corps SAM.

Advanced concepts employs a rigorous new-start process which emphasizes reduced cost and advanced technology. Research and development is conducted in areas of interest based on CINC and user input. Technology and manufacturing processes are continuously developed and refined to reduce costs and counter the threat. Advanced technology demonstrations are conducted to

Figure 2-14. Core Programs Unit Costs And Production Rates

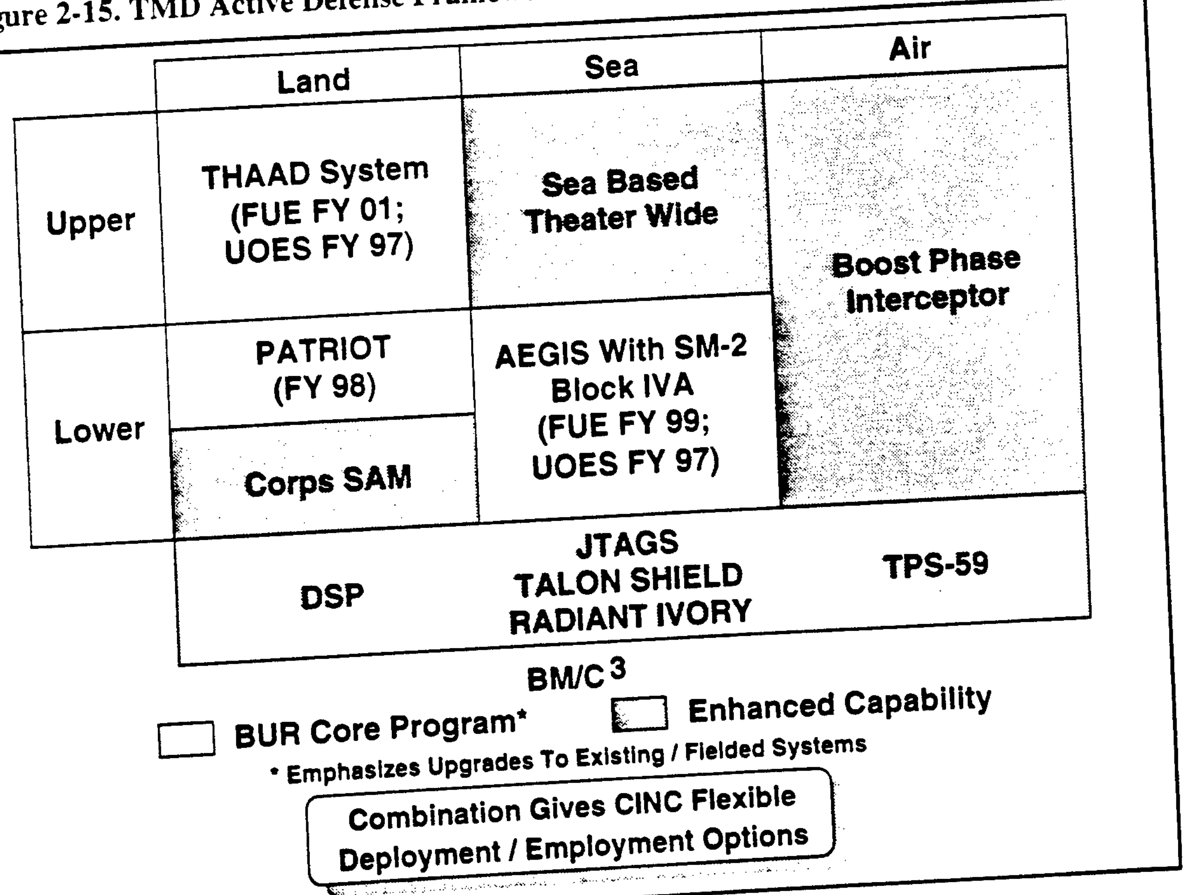
Core Program		Average Unit Production Cost TY $M	Type	Production Rate (Delivery Schedule) Fiscal Year 97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	Total
PAC-3	ERINT	1.8*	LRIP**		52	140																		192
			FRP			140	432	456	280															1,308
THAAD System	THAAD	3.7*	LRIP					59	128	88														275
			FRP							136	352	364	186											1,038
	TMD-GBR	167.5	LRIP					1																1
			FRP						2	3	3	3	2											13
Sea Based Area TBMD	AEGIS / SM-2	2.4*	LRIP			55	90																	145
			FRP					90	200	200	200	200	200	200	65									1,355

* Production Cost Per Missile
** LRIP - Low Rate Initial Production
FRP - Full Rate Production

provide early assessment of manufacturing capability and acquisition risk in addition to cost and affordability analyses. An advanced concept is considered for a new start based on national priorities, maturity, capability, effectiveness, lethality, current and projected threat, operational need, and affordability. If selected for a new start, the advanced concept enters the DAB process. If not selected, additional R&D may be conducted to further refine the technology and the manufacturing process and to reduce cost.

Currently, three programs are being considered under advanced concepts: Corps SAM, Sea Based Theater Wide Defense, and Boost Phase Intercept. Corps SAM will provide an easily deployable defense for highly mobile land forces. Sea based theater wide defense will provide a worldwide capability to defeat long-range TBM threats without the need for forward basing. Boost phase intercept will counter submunitions and reactive threats by engaging TBMs early in their flight paths over enemy territory. Figure 2-15 shows the advanced concepts and the core programs within the TMD active defense framework.

Figure 2-15. TMD Active Defense Framework Core Programs And Advanced Concepts



2.10 TMD Test Program

2.10.1 Test Program Responsibilities

TMD testing consists of individual acquisition program testing and TMD interoperability tests. The majority of TMD test and evaluation (T&E) efforts will be accomplished by the individual acquisition programs and will encompass all requirements mandated in DoD guidance. These test programs will be documented in the program specific Test and Evaluation Master Plan (TEMP). Testing to assure interoperability between systems acquired by an individual Service will generally be accomplished by that Service.

BMDO will sponsor testing to assure interservice operability and interoperability of the TMD system with external systems. TMD system test requirements are derived from the Ballistic Missile Defense Capstone Operational Requirements Document (ORD) and from each of the individual element ORDs. Those requirements that are not addressed in the program specific test programs are included in the TMD Integrated Test Plan (ITP), which is the executing document for the TMD Integrated Test Program. The ITP is a road map for future detailed test planning and coordination among test programs, resources, agencies, and other appropriate organizations.

A management team -- the Test and Evaluation Working Group (TEWG) -- has been established to implement TMD system level testing. The planned test program is documented in the TMD ITP. Interoperability certification will be provided by the Joint Interoperability Engineering Organization as required by DoD Directive 4630.5 and JCS MOP 160.

All tests will be conducted in accordance with existing U.S. treaty obligations.

2.10.2 Modeling and Simulation

BMDO makes extensive use of models and simulations, some of which include hardware in the loop. The use of simulations, models, and test beds for each system is specified in each system Test and Evaluation Master Plan (TEMP). BMDO's executing agents for TMD development will make use of existing modeling and simulation capabilities developed and funded by BMDO and the Services. Each system will utilize system-unique models and simulations within their testing program, particularly in the early phases, to gain confidence, assess risks, identify technological limitations, and perform trade-off analyses. These models and simulations will serve to expand the current BMDO test facility base. Each model and simulation used in the test and evaluation programs will be formally verified, validated, and accredited for its particular use.

To ensure the models and simulations are credible, BMDO has established a formal Validation, Verification, and Accreditation (VV&A) process. Each model and simulation used in the test and evaluation program goes through this process. The VV&A process has been reviewed by the OSD staff and received high praise as a model for other DoD organizations.

The large number of engagement possibilities, constraints on test scenarios, lack of control of the natural environment, safety, and very large costs are but a few of the challenges that limit live integration testing. To overcome these limitations, BMDO has several simulations and facilities to support the test program. Key elements include the National Test Bed (NTB), the TMD System Exerciser, and TMD system and technology simulations.

The National Test Bed (NTB) is composed of a network of DoD research facilities geographically distributed across the continental United States. These research facilities include the Army's Advanced Research Center in Huntsville, the National laboratories, and other service laboratories.

At the hub of this network is the National Test Facility (NTF), located at Falcon Air Force Base, Colorado. All of the facilities within the NTB are tied together through secure communication links which offer secure access to resources available at the NTF. The purpose of the NTF is to:

- Provide a comprehensive simulation environment to support ballistic missile defense design, development, and testing.

- Provide real-time simulations to explore TMD operational concepts.

- Support air defense, theater missile defense, and space based asset integration and control studies.

- In the long term, become a more general research and analysis center, maintaining a world class computational capability and the expertise and tools to support national priority programs.

- Provide users a verification, validation, and accreditation capability for other modeling and simulation tools.

The NTF provides analysis activities that employ a full spectrum of simulations, test and evaluation tools, architecture and systems models, threat models and element level tools. The NTF has a significant networked man-in-the-loop simulation capability. The NTF analyses provide insight, technical findings, and recommendations in support of customer requirements. Below is a description of a small sample of the capability available.

- The Theater Planning Tool is a fast running, batch processed, end-to-end architecture analysis tool that supports a broad spectrum of hardware, deployment planning, and test planning analysis. It allows very flexible and rapid reconfiguration of simulated architectures and element design features and functions.

- The Battle Management/Command, Control, and Communications Element Support Center provides a centralized environment for integration, testing, and analysis of products that have been developed throughout the BM/C^3I community. The environment allows BMDO to evaluate the effectiveness and interoperability of various BM/C^3I elements.

- The NTF Wargame Simulator provides a capability for evaluating human-in-control for large-scale missile defense exercises. The NTF provides the wargame facility with individual command and control positions and the threat and space elements. The NTF networks to other wargame facilities for the detailed models and human in control positions needed for individual exercises. BMDO has several major TMD wargames and other exercises scheduled for FY 1994 and FY 1995.

The Army's Advanced Research Center (ARC) in Huntsville provides computational support to the entire group of Huntsville's missile research and development organizations including the U.S. Army Space and Strategic Defense Command, the U.S. Army Missile Command, and the PEO Missile Defense. The ARC includes a large array of modern, special and general purpose computing hardware, a phenomenology library with over 20 years of data on strategic and theater missiles, and superb facility and software resources for missile scientists. This facility, which hosts the Extended Air Defense Test Bed (EADTB) and the Surveillance Test Bed, is the development center for the Theater Missile Defense System Exerciser. The ARC has an advanced wargame facility, interconnects to several CRAY supercomputers, and is networked to a number of other DoD development facilities.

The Theater Missile Defense System Exerciser (TMDSE) is being developed to help resolve some of the major theater integration and interoperability issues, both inter- and intra-service. It will provide a real-time, dynamic, tactical hardware-in-the-loop, system level test capability. The TMDSE allows for extrapolation from few-on-few system integration tests to full engagement scenarios in any feasible environment. The heart of the TMDSE is a test and control node and a theater environment node which will utilize Extended Air Defense Simulation (EADSIM) and EADTB when available to generate the threat scenario. (EADSIM and EADTB are described below.) A coordinated threat is then presented to all the TMD elements hooked into the TMDSE in real time. Tactical operators for these elements will provide the dynamic interface. The TMDSE will provide the means to evaluate the operation of the TMD system under full loading and in the presence of countermeasures.

In FY 1994 TMDSE activities will include a demonstration of the capability to link the JTAGS prototype system at White Sands Missile Range and the PATRIOT Flight Mission Simulator in Bedford, Massachusetts with the Advanced Research Center in Huntsville. In FY 1995 the TMDSE will add an AEGIS weapon system node in Dahlgren, Virginia and move the PATRIOT node to the Software Engineering Directorate in Huntsville. Plans also call for integrating the Control and Reporting Center functions at the Theater Air Command and Control Simulation Facility at Kirtland AFB, New Mexico.

EADSIM is a multinational system simulation standard for air defense and TMD studies. Hosted on a single workstation, it was used as a preplanning tool for Desert Storm and has an installed base of over 200 systems worldwide. EADSIM is a low-to-medium fidelity model of air and missile warfare used for scenarios ranging from few-on-few to many-on-many. Each platform (such as a fighter aircraft) is individually modeled, as is the interaction among the platforms. The model permits an analyst to evaluate system technical and operational performance, command and control, and engagement processes for selected platforms in a variety of battle scenarios. EADSIM supports architectural analysis and limited system engineering analysis, cost and operational effectiveness analysis, and acceptance testing.

The Extended Air Defense Test Bed will provide a high fidelity, flexible, user-friendly, computer based simulation tool for traditional air defense experiments with the added complexity of the theater missile defense threats. It is oriented to large scale scenarios for system analysis and COEA support. The system will be capable of analyzing full theater level scenarios and will permit evaluation of extended air defense systems. Key attributes of the EADTB include an advanced state-of-the-art graphics interface; highly interactive user control of models and scenario design; an accredited models library; extensive and flexible run time and post processing analysis support; flexible BM/C^{3}I rule sets; low and high fidelity models that can be intermixed per user request; detailed physical models of phenomenology; and all development with Ada. Initial node installations are complete at SHAPE Technical Center, Advanced Research Center, and Fort Bliss. Additional nodes are planned for Kirtland Air Force Base and the NTF. When operational in mid-FY 1994, BMDO will proceed to run a series of BM/C^{3}I experiments on the EADTB to evaluate the simulation system and provide data for BM/C^{3}I architecture studies.

2.10.3 Live-fire Test Certification

The objective of Live-Fire Test And Evaluation (LFT&E) is to support a timely and thorough assessment of each system's lethality as it progresses through its development and subsequent production phases. The primary emphasis of the program is on realistic testing as a source of lethality information to ensure potential design flaws are identified and corrected prior to full-rate production.

Live-fire lethality testing will be performed as directed in the DoD 5000 Series documents and the amendments to Chapter 139 of Title 10, United States Code. The DoD 5000 Series documents require live-fire testing be conducted before a decision for full-rate production but after a decision for low-rate initial production. BMDO has established and manages a core lethality effort to support common issues and reduce total costs. Each program office is responsible for developing a LFT&E program in conjunction with the BMDO provided core effort. The LFT&E program represents the best alternative to "actual" combat in assessing the systems performance.

Results from LFT&E will be combined with operator-in-the-loop and analytical simulations to extend the results into larger and more stressing scenarios for theater level, force-on-force analysis. Data from live tests will be used to help validate simulation results. Simulation will also be used prior to live tests to assist in planning, scoping, and rehearsing scenarios, and to gain insight into expected performance at the live-fire ranges.

Section 237 of the National Defense Authorization Act for Fiscal Year 1994 requires that live-fire testing for TMD interceptor programs be completed before proceeding into low-rate initial production thus limiting the test to EMD missiles. The Act also requires that live-fire testing involve multiple interceptors and multiple targets in the presence of realistic countermeasures. To successfully complete these tests requires the use of production representative or LRIP missiles. These missiles are not available until very late in the EMD phase. The requirement to complete tests <u>before</u> LRIP will cause a substantial schedule delay and increase program cost by several hundred million dollars.

A legislative proposal to amend Section 237 to expand the methods of test and evaluation used to demonstrate interceptor performance was included in the Department's omnibus bill proposal for the legislative program for the second session of the 103d Congress. The proposal would also provide that the testing be completed before proceeding <u>beyond</u> low-rate initial production.

2.11 Summary

BMDO is aggressively pursuing an affordable, cost effective, robust, treaty compliant TMD system. The comprehensive CINC TMD Experiments Program and the near term improvements are providing the CINCs and Services a focused program for the development of doctrine, tactics, and training while making maximum use of existing capabilities. Our leadership in establishing a joint BM/C^3I architecture ensures multiservice interoperability. These efforts are having an effect now. The core program will provide a substantial TMD capability with no overlap or duplication of other existing or planned programs. The advanced capabilities effort provides essential, complementary capabilities to the core program. The synergistic effect of these efforts will lead to an effective TMD capability that "...protects U.S. forces, U.S. allies, and other important countries including areas of vital interest to the U,S."

Chapter 3

Limited Defense System (LDS) Development Plan

Chapter 3
Limited Defense Systems (LDS) Development Plan

3.1 Introduction

The National Missile Defense (NMD)[1] architecture developed in response to the Missile Defense Act of 1991, as amended, consists of Ground Based Interceptors (GBI) and a Ground Based Radar (GBR) at an ABM Treaty compliant site; a Battle Management, Command, Control and Communications (BM/C^3) complex; and a constellation of Space and Missile Tracking System (SMTS)(formerly Brilliant Eyes) satellites. This architecture is shown schematically in Figure 3-1. The objective architecture continues to be the basis for program development and will guide the NMD Technology Readiness Program. Although the objective architecture is consistent with the FY 1993 and FY 1994 President's Budget and Reports to Congress, it is important to note that the 1993 Report to Congress discussed an NMD acquisition plan while the 1994 Report to Congress discusses a technology readiness program. Features of the 1993 and 1994 programs are summarized in Figure 3-2. During the course of the technology readiness program, the architecture will be reassessed periodically to determine if it remains an appropriate approach for a rapid response, contingency deployment to meet ballistic missile threats to the U.S. homeland.

3.2 Program Strategy

The NMD threat environment can be characterized by uncertainty in the timing of a ballistic missile threat to the U.S. homeland. Waiting for the threat to emerge before responding could result in grave consequences since an acquisition program such as that described in the 1993 Report to Congress takes a relatively long time to deploy. Therefore, the basic strategy for NMD is to preserve the opportunity to field timely and effective ballistic missile defense for the U.S. homeland. This program which is less than an acquisition and deployment commitment is designated the NMD Technology Readiness Program. It is designed to develop the objective system capability by progressively establishing increasingly capable options to deploy. The program retains the flexibility to continue as a technology readiness program, breakout into a contingency deployment, or transition to an acquisition program.

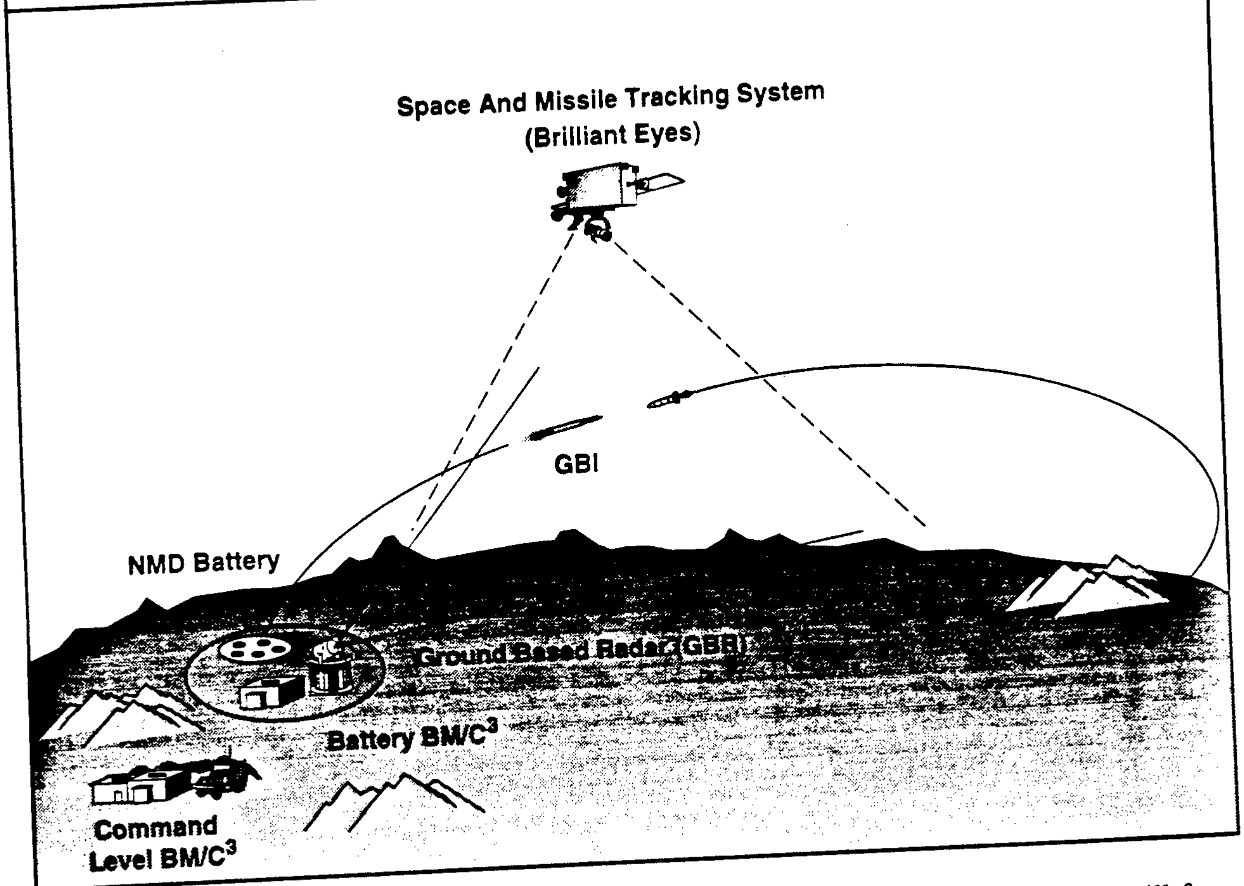
The NMD Readiness Program will focus future investments on resolving key system level technical challenges. This work includes technology development as well as planning to reduce deployment lead times. The program will also use past BMDO and DoD investments and leverage TMD programs.

3.2.1 Evolving Technology Readiness

A key feature of the NMD technology readiness program is that as technology matures, deployment opportunities with increased system effectiveness will be available. Significant increases in technology capability are expected by the end of the following time frames: early FY 1995-1997,

[1]Limited Defense System (LDS) will be referred to as National Missile Defense (NMD) throughout this chapter of the report.

Figure 3-1 NMD Objective Architecture



mid term FY 1998-2000, and objective system FY 2001-2003. Deployment planning will focus on reduction of lead times and risks and will be updated on an annual basis.

The investment strategy for FY 1995-1997 will focus on improving the elements of the objective system and performing contingency analysis and deployment planning. The highest priority is the Exoatmospheric Kill Vehicle (EKV) project. The emphasis is on maturing kinetic kill vehicle technology to establish confidence that we can reliably "kill a bullet with a bullet." Planning activities that will reduce deployment lead times will also be pursued. Initial battle management software capability will be developed by evolving TMD battery level BM/C^3 for strategic defense. NMD radar work will leverage TMD radar development. Radar technologies which address NMD unique issues will be pursued.

The objective for FY 1998-2000 is to continue development toward the objective system capability while also reducing risks. Deployment planning during this time period will receive additional emphasis. The EKV will be integrated with a radar technology demonstrator. BM/C^3 capabilities will be improved. The SMTS program will launch two flight demonstration satellites with MWIR sensors and demonstrate space based sensor cueing. Technology infusion programs will continue.

For FY 2001-2003, the goal is to complete technology readiness of the NMD objective system

Figure 3-2. Transition To NMD Technology Readiness Program

FY 93 Report To Congress On BMD	FY 94 Report To Congress On BMD
NMD System Acquisition	***NMD Technology Readiness***
• Acquisition Strategy - Threat (GPALS, Up To 200 RVs) - Core Program For Single Site System Acquisition - UOES Contingency Deployment Option - Multisite NMD Architecture	• Technology Readiness Strategy - Threat (Limited Number Of RVs) - Element Technology Development - Contingency Responses Deployable At Anytime - Demonstrate Objective Architectural Capability In FY 04 At An ABM Treaty Approved Site
• Initial Capability Of Single Site (Production Level): FY 04	• *If A Deployment Decision Is Made And Funded Beginning FY 04* - Initial Objective Capability Of Single Site (Not Production Level): FY 08
• UOES Contingency Deployment At Initial Site In FY 00, *If UOES Decision Made In FY 97* Note: Acquisition Program Continues With Parallel Technology Development For Production Of Initial Capability For First Site Deployment	• Initial Capability Of Single Site As Early As FY 02, *If Contingency Decision Made In FY 97* Note: Parallel Technology Program Could Continue Toward Objective Capability
• Multisite Deployment In FY 06-12	• Planning For Single Site Only

capability. The EKV and booster are integrated into an interceptor with subsequent flight testing. The LWIR SMTS will be developed. Technology infusion programs will also be supported throughout this time period for possible future insertion into NMD elements. In addition, updates to contingency deployment planning will continue.

In developing the Technology Readiness Program, priority is placed on using the time and dollars available to pursue the most technically challenging activities, or "long poles." Activities identified as long poles are known to be difficult, require a long time to complete, increase performance, or have high payoff with desired outcome. Key technical challenges will be resolved during the Technology Readiness Program. Representative technical challenges are:

Interceptor	
KV & Seeker Design	- Increase seeker sensitivity, decrease KV weight
- KV Dormancy	- Increase reliability and availabilty
Hand over/Field of View	- Achieve higher divert velocities, increase field of view
Endgame Target Object Map	- Improve target selection and aim point selection
Sensors	
Cryocooler Performance	- Achieve long life and high reliability, low temperature, low vibration, and enhanced stability
Optics Producibility	- Produce radiation hardened mirrors with required performance
Sensor Discrimination	- Develop new algorithms and collect X-band and optical data on targets and background
LWIR FPA Producibility	- Increase yield and improve low noise performance
BM/C³	
Information Architecture	- Develop for system with rigorous real-time system requirements
Real-Time Distributed Data Bases	- Develop concurrency of data across multiple nodes
High-speed Network Security	- Develop new capability to provide end-to-end encryption of links
Interfaces	
BM/C³ to Interceptor	- Correlate RF data with SMTS IR data to produce accurate Target Object Maps (TOMs)
High Risk Trade Studies	- Specify sensor hand over error and interceptor seeker field of view and performance with high confidence

3.2.2 *Deployment Planning*

The process of developing deployment plans begin with identified objectives associated with a particular deployable option. As discussed earlier, deployable options will be available throughout the path leading to the objective system. Specific deployment requirements for a particular option will be fully defined during the applicable period. NMD studies and TMD programs will be important sources for determining those requirements. Even more important is the information resulting from analysis and tests performed throughout the NMD Technology Readiness Program. The real challenge is to identify associated risks that have high potential for impacting deployment times. This can be particularly challenging in certain cases where NMD unique deployment requirements are difficult to address. We will emphasize simulation and modeling methods to address this. Extensive simulation and modeling methods available through government facilities such as the National Test Bed (NTB) will be used in such tasks as analyzing support operations, determining manpower estimates, and establishing construction requirements. In the case of manufacturing and producibility, computer modeling will be used to determine engineering development requirements and potential production line bottlenecks. Once risk areas have been determined, applicable plans on how to mitigate risks will then be developed.

One approach that can significantly reduce deployment lead time is stockpiling of selected time critical components. Although no decision has been made on the use of stockpiling, it is a viable option which could reduce deployment lead times. Since stockpiling selected time critical components can be costly, trades between stockpiling, deployment time, and system capability will be performed and assessed to determine the scope of its applicability.

A test and evaluation program for contigency deployment will be developed. Planning efforts will be focused on how verification and confidence levels of components and systems can contribute to contingency deployment. Test strategy, availability of hardware and facilities, and analysis assessments will be considered. These efforts will be adjusted based on assessments of technology maturity and resulting deployment requirements. Other factors which will affect test planning include changes in the national testing capabilities and test facilities infrastructure, training, manpower, and capabilities of system users. These will be tracked and monitored, and will be incorporated into deployment decisions.

Other deployment readiness planning areas have also been identified and include the following: environmental compliance requirements, site selection and activation planning, deployment cost estimates, maintenance concept, and human system integration assessment, personnel and training. Also part of the planning process is the assessment of industrial base capabilities and early operational suitability assessments. These options will be updated so that as technology matures, adjustments will be made to reflect increases in capability, reduced deployment times, and reduce risks.

The potential to reduce deployment lead time will be developed, but an important factor in achieving successful deployment is the iterative development process involving designers and operators. Operators will play an integral part of the process in developing the concept of operations which will aid further determination of specific system requirements.

3.2.3 Deployment Opportunity and Threat

An early term deployment capability could result from deployment of the following elements: Defense Support Program (DSP) for early warning surveillance, upgraded early warning radar as the midcourse sensor, a ground based kinetic kill interceptor based on the EKV, a ground based radar as an active sensor based on the TMD-GBR, and the first block BM/C^3. A single site, treaty compliant system providing limited defense for the Continental United States (CONUS) against a small number of large, warm unpenaided warheads could be deployed.

For the mid term option, the deployable elements continue to include DSP, a better integrated and tested ground based radar, upgraded early warning radars, a ground based interceptor based on an improved Exoatmospheric Kill Vehicle (EKV), and the second block BM/C^3. A medium wavelength infrared (MWIR) capable SMTS would also be available as an over the horizon, midcourse sensor. This option would also be single site, treaty compliant. Limited defense protection for CONUS and Alaska is possible against a small number of large warm warheads and a small number of small cool warheads.

For the objective system option, the deployable elements include DSP (or DSP follow-on), Ground Based Radar (GBR), an LWIR SMTS as the passive midcourse sensor, Ground Based Interceptor (GBI), and the third block BM/C^3. Deployed as a single, treaty compliant site, the objective system could provide a high level of protection for CONUS and Alaska. In addition, limited defense protection could be possible against multiple warheads with contact fusing and penetration aids.

In all deployment opportunities discussed above, higher levels of protection are possible with a multiple site defense system. However, this approach is not treaty compliant.

3.3 Element Development

The baseline NMD architecture includes the NMD battery, which consists of the GBI, the GBR, and the Battery BM/C^3. The Battery BM/C^3 interfaces with Command level BM/C^3 and performs integrated engagement operations.

The following is a description of the development of each element of the baseline NMD architecture.

3.3.1 Ground Based Interceptor

The Ground Based Interceptor (GBI)[2] is designed for hit-to-kill (nonnuclear) intercepts of Intercontinental Ballistic Missile (ICBM) and Submarine Launched Ballistic Missile (SLBM) reentry vehicles (RVs) in the ballistic midcourse phase of their trajectories. Midcourse sensors (such as GBR, SMTS satellites and early warning radars) will acquire, track, and transmit threat data to the BM/C^3 system. The BM/C^3 will cue the ground based radar, commit the interceptors, and provide updates as available. Using on board sensors and data from SMTS and GBR, the interceptors will acquire the threat cluster, select the enemy reentry vehicle, and through body-to-body impact (kinetic kill), destroy it.

The strategy for GBI development concentrates initially on the difficult technical issues of the interceptor front end, the Exoatmospheric Kill Vehicle (EKV). Booster development for the NMD interceptor is not a long pole technical issue and will be addressed later with new contracts. The competitively awarded GBI-X contracts, in place since October 1990 to address EKV technologies, have been selected to meet early NMD technology readiness requirements. The Army managed program will also include Air Force and Navy input for a more generic EKV development. A joint service coordination group has been established to refine the program content and to ensure the products are responsive to multiservice EKV needs. The program, renamed EKV to reflect the multiservice aspects and the broad nature of the GBI-X contracts, is shown in Figure 3-3.

[2]GBI is comprised of three main subsystems: Exoatomospheric Kill Vehicle (EKV), booster and launch/ground support equipment, and command and launch equipment. The EKV is also referred to as the Kinetic Kill Vehicle (KKV) or kill vehicle (KV).

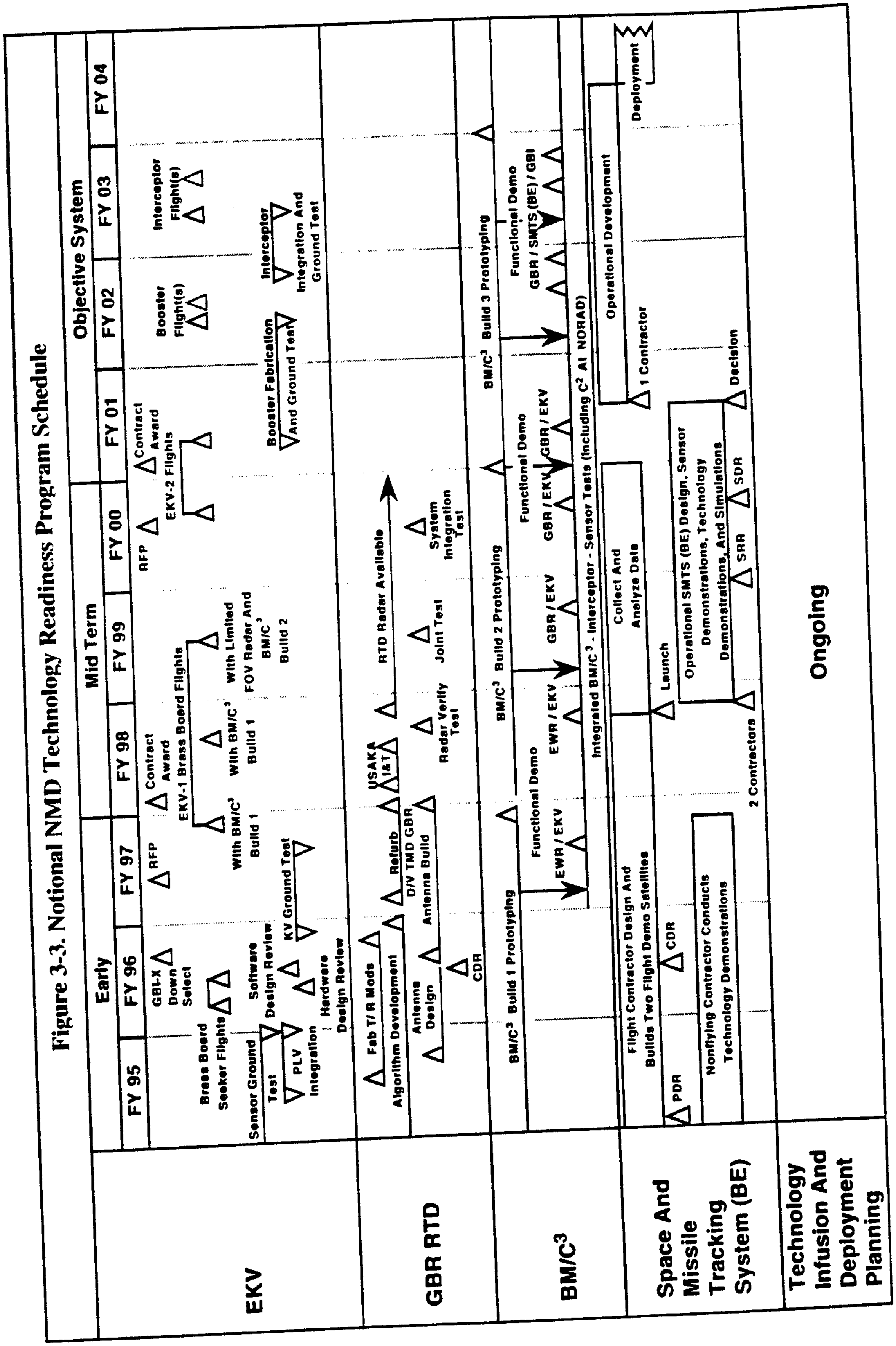


Figure 3-3. Notional NMD Technology Readiness Program Schedule

For FY 1995-1997, objectives for the EKV research and development effort are to expand the engagement envelope through improvements in on board sensor acquisition range, discrimination, aim point selection, and divert velocity. These improvements will require iterating design, fabrication, and testing over the next three to four years. In FY 1994 the EKV contractors will mainly conduct ground tests of their brass board seekers. Contractor down selects are planned in the third quarter of FY 1994 and again in FY 1996 following a design review and sensor flight tests. The remaining EKV contractor will complete kill vehicle design, fabrication, integration, and Hardware-In-The-Loop (HWIL) ground testing prior to a planned intercept flight test against a threat representative target in late FY 1997.

During FY 1998-2000, we will accomplish infusion of technology advances and/or other mission requirements and demonstrate, through HWIL ground testing and flight testing, increased reliability, effectiveness, and EKV/Radar/BM/C^3 interoperability. In addition, performance will be tested using threat representative targets. By FY 2000 the EKV will be characterized in a limited operational environment with most active sensor interface issues addressed.

To complete technical readiness of the objective system, development efforts will systemize the EKV into an interceptor by developing and integrating booster and ground support interfaces and demonstrating interoperability with advanced sensors and the latest BM/C^3 configuration. Plans exist to develop advanced interceptor sensor and target selection capability depending on the status of the threat. Integrated testing and manufacturing issues would be addressed to further reduce contingency deployment time lines.

Interceptor technology development during FY 1995-1997 will be conducted to reduce risk and cost of the EKV. Technology programs in these areas are currently in progress. They emphasize nuclear hardened LWIR focal plane array producibility and automated testing, discrimination software, communication, materials, and structures. During FY 1998-2000, technology programs in lightweight LADAR, active sensor packaging, wide field of view cooled optics and divert propulsion will be conducted. These programs will enhance mid term EKV-2 capability if the threat requires such a response. In a few cases, where more time is needed to develop the technology, these programs will begin during FY 1995-1997. During FY 2001-2003, the EKV and booster will be synthesized into an interceptor to demonstrate its required performance. Also, technology programs may include integrated active/passive sensor, on board active/passive discrimination and a retina (smart) sensor.

In summary, this evolutionary development of a GBI for National Missile Defense provides a low risk, methodical approach to address both technical issues and funding limitations. This strategy does not include a planned entry into system development but continues to protect an evolving deployment option should fielding be required.

3.3.2 *Ground Based Radar*

The NMD-GBR will detect, acquire and track Reentry Vehicles (RVs) and provide support data to the BM/C^3, which combines data from all available sensors and transmits the data to the interceptor during exoatmospheric engagements. The NMD-GBR can operate autonomously or use range-extending cueing support provided by BM/C^3 for other space and ground based sensors.

The NMD-GBR provides data to support weapon target assignment, sensor fusion, kill assessment, and employment option decisions. The NMD-GBR will also provide data to support precision tracking, impact point prediction and signal/data processing for exoatmospheric discrimination and classification in support of the interceptor.

The NMD-GBR program was restructured into a Radar Technology Demonstration (RTD) program that will leverage theater missile defense ground based radar developments to resolve critical issues in a cost-effective manner. The basic NMD-GBR design was originally planned to utilize traveling wave tube technology, but will now use solid-state technology to fully leverage TMD-GBR investment. Initial efforts of the restructured program will resolve the following critical NMD-GBR technology issues: discrimination, target object map, mechanical/electronic scan, and kill assessment.

The RTD program (see Figure 3-3) will transition from algorithm development to real-time software and hardware-in-the-loop simulation, and finally to radar technology testing as follows:

- Enhance TMD software for NMD applications;
- Code newly developed NMD algorithms;
- Develop NMD real-time simulation to run on an existing NMD-GBR data processor driven by simulated data;
- Demonstrate software performance;
- Support integrated testing.

A key technical activity is the installation of the RTD demonstrator at the Kwajalein Missile Range. In FY 1995, the RTD would be extended in two ways: (1) conduct hardware-in-the-loop efforts to resolve a higher percentage of the critical issues, and (2) test additional existing TMD hardware to validate and resolve NMD critical issues. In the second increment, the TMD-GBR Dem/Val radar hardware will be converted to a larger, limited field-of-view unit which has sufficient range to support NMD requirements. Also starting in FY 1995, additional solid-state Transmit/Receive modules would be purchased for the conversion of the TMD-GBR Dem/Val radar into the RTD. The conversion would start at the end of FY 1997 and the RTD would be available to support integrated testing in FY 1999. Later, this radar will be used in integrated testing with EKV and eventually the entire NMD system.

The radar technology program supporting the NMD-GBR is formulated to provide a technical base for GBR. This program develops the advanced radar technology base necessary to meet the functional performance requirements of large aperture, phased array radars to support ballistic missile defense during all phases of threat flight. Emphasis is placed upon endo- and exoatmospheric tracking, fire control, and engagement functions with focus on developing solid-state RF components, fiber optic interconnects and waveform generating and processing components.

3.3.3 Space and Missile Tracking System

The Space and Missile and Tracking System (SMTS), formerly known as Brilliant Eyes (BE)[3], is a space based sensor system equipped with a suite of Short Wavelength Infrared (SWIR), Medium Wavelength Infrared (MWIR), and Long Wavelength Infrared (LWIR) and visible sensors designed to support strategic and theater ballistic missile defense. A constellation of SMTS satellites provides global tracking of ballistic missiles in their boost, post boost, and midcourse phases in response to directed tasking from the BM/C³ system. In peacetime, SMTS operations include supporting Air Force space surveillance missions and monitoring and collecting data on ballistic missile tests worldwide.

SMTS tracking data supports command and control, active defense, passive defense, and attack operations by providing highly accurate estimates of the inbound missile's trajectory. SMTS provides continuous tracking of ballistic missiles in flight to support situational awareness, apportionment, and the optimum allocation of defense assets. SMTS provides support data to the BM/C³, which combines the data from all available sensors and transmits the data to the interceptors. SMTS provides data to support weapon target assignments, target discrimination, kill assessment and employment option decisions. As an over-the-horizon sensor, SMTS allows the interceptors (ground based interceptors, theater high altitude area defense and sea based upper tier) to have the maximum time for fly out, generating the largest possible defended area from each interceptor site. To increase radar detection range, SMTS cues ground and ship based radars so they can focus their energy into smaller volumes to acquire the reentry vehicles earlier. The interceptors can be launched and updated based on SMTS track data. SMTS data can be converted into accurate reentry vehicle impact point and time predictions, enabling defensive measures to be taken.

SMTS sensor development will continue toward the objective capability (see Figure 3-3). The strategy for SMTS development concentrates on technology maturity, performance, and producibility of the most stressing technologies and functional demonstrations of sensor and system design and operations. In FY 1995-1997, the objectives are to demonstrate technology maturity and performance of the focal planes, cryocoolers, processors, and communication components and demonstrate the sensor performance and validate the design through software computer simulations and hardware-in-the-loop demonstrations.

During FY 1998-2000 the flight demonstration satellites will be launched. These satellites will demonstrate all the functional operations of the SMTS, collect phenomenology data, and demonstrate technology performance. Although not in real time, these satellites will also demonstrate interoperability with TMD elements through joint tests and off-line data analysis. The flight demonstration satellites will not have the full complement of sensors necessary for NMD support. Ground tests of prototype, flight-ready long wavelength infrared sensors will provide validation of the design and performance of the more advanced sensors necessary for NMD support. This data in concert with the on-orbit flight demonstration data will demonstrate all critical operational issues and fulfill decision criteria for a deployment decision.

For the objective system period FY 2001-2003, the focus will be on operational issues, design,

[3]Although management of BE transfered to the Air Force in FY 1994, this plan includes a discussion of BE because it is an integral part of the Ballistic Missile Defense system. Also, the FY 1995 DoD budget funds the BE program, now SMTS, through BMDO beginning in FY 1995.

and advanced sensor testing as risk reduction. Fabrication of advanced demonstration satellites with the full complement of sensors will be complete and integrated tests with NMD systems performed using the flight demonstration satellites in a non-real-time mode.

Technology development programs supporting SMTS will include LWIR FPA producibility and performance, 20/44/60 gigahertz communications, 10° Kelvin, 40° Kelvin, and 60° Kelvin cryocoolers, and radiation hard avionics. These programs will be conducted to enable capabilities required of the SMTS constellation.

Currently, the SMTS program is in the demonstration and validation phase with two contractors. Transitioning from acquisition to part of the technology readiness program with two contractors is under review. Restructuring the SMTS contracts will occur in FY 1994 to one contractor to develop and fly two flight demonstration satellites and the other contractor maintained as risk reduction in techology development, system design, and system engineering.

3.3.4 Battle Management Command, Control, and Communications

Ballistic Missile Defense (BMD) Battle Management Command, Control, and Communications (BM/C^3) systems provide the mechanisms and interoperability necessary to execute the United States Space Command Concept and Operations (CONOPS). Also, it will provide support to all operational aspects of command, control, and communications. Human-in-control decision processes are required to select and issue system control directives. System control is used to carry out CINC directives involving sensor tasking, communication tasking, weapon tasking, data fusion, and other functions. The Battery BM/C^3 includes a single interface to the Command level BM/C^3. Multiple types of command and data are provided to the Battery through this interface, including sensor tasks, weapons release, battle strategies and tactics, Early Warning and SMTS sensor data, and tasking to support engagement planning based on SMTS precommit data, if and when applicable. Battery BM/C^3 engagement planning operations will control the development of fire control solutions for battle execution.

BM/C^3 systems will be a combination of existing, modified and new capabilities consisting of human-in-the-loop methods, processors, software, and communications media. Since BM/C^3 controls system behavior and drives element interfaces, BM/C^3 must be designed, evaluated, and updated with user interaction. Incremental blocks of BM/C^3 prototype developments will be used to evolve required NMD functional capability (see Figure 3-3). Each incremental software build will be evaluated by the user (USCINCSPACE) to ensure the final software block represents the system behavior required. User involvement is key in helping to reduce development and deployment times.

The Battery BM/C^3 effort will focus initially on weapons control/communication/engagement software, and human-in-control functions, demonstrating these functions with commercial hardware. During FY 1998-2000, the Battery BM/C^3 will address the sensors control/integrated/ engagement planning capability, completing the remaining Battery BM/C^3 functions, and refining the human-in-control functions to include the Commander-in-Chief (CINC) interface for this second build. The Battery Engagement Planner component will leverage Build 1 and Build 2 prototypes from existing BM/C^3 algorithms, simulations, and hardware-in-the-loop capabilities plus use of THAAD and TMD developed communications hardware and software and BM/C^3 algorithms.

The strategy involving close user interaction is as follows: (1) develop an interactive object oriented prototype BM/C^3 software architecture; (2) construct a hardware network to implement the BM/C^3 architecture and connectivity to weapons/sensors; and (3) provide a virtual environment including real-time distributed data bases to demonstrate the BM/C^3 network under various threat conditions.

BM/C^3 philosophy will follow two criteria: (1) evolution from top-down requirements, and (2) interface support provided from current/modified system, evolving functionally to the objective system. In FY 1995-1997, limited capabilities will support FY 1996 EKV tests evolving to an Integrated Flight test demonstrating BM/C^3 in-line to interceptor operations. BM/C^3 places tests in an operational context by using surrogate sensor processing, limited engagement planning, human-in-control, situation support, and basic communications planning and scheduling. BM/C^3 block developments will also demonstrate end-to-end operations through sensor processing, sensor planning and scheduling, sensor correlation and hand over, enhanced decision aids, and real-time In-flight Target Update (IFTU)/Target Object Map (TOM). During FY 1998-2000, block developments will demonstrate BM/C^3 through complete decision support environment and external system interfaces, operational demonstrations, peacetime operations, and the application of fielded TMD lessons learned. A key feature in this time period is for BM/C^3 to integrate the RTD demonstrator with the EKV. During FY 2001-2003, the program will demonstrate that critical BM/C^3 technologies can be incorporated into the open architecture, prove critical processes are understood and attainable, develop information to support transition, and establish the baseline cost, schedule and performance objectives.

BM/C^3 technology will include 20/44 gigahertz communications, programmable modem and ground entry point antenna, and high-speed network security. These technologies will enable the BM/C^3 capability needed for FY 1998-2003. Processes demonstrated over the past years prove the reliability of incrementally maturing BM/C^3 capabilities. Under the Technology Readiness Program, a command and control facility is envisioned in Colorado Springs, Colorado and an engagement planning facility at Huntsville, Alabama to serve as demonstration and validation test facilities. The facility will also have the potential for upgrade for advanced testing or operational use.

3.4 TMD Program Leveraging

The Technology Readiness Program will capitalize on those technologies matured through development and fielding of theater missile defense systems. The development of ground based radar for the TMD, which has a high degree of commonality with the radar envisioned for NMD, will reduce costs and lead times for NMD-GBR. It is anticipated that approximately $70M will be saved and 65-70% of the TMD-GBR hardware/software development will be common to the NMD-GBR development. The Radar Technology Demonstration (RTD) program will leverage off the TMD-GBR program in both the software and hardware areas. NMD-GBR unique critical issues of discrimination, target object mapping, mechanical and electronic scan, and kill assessment will be resolved separately and integrated into the RTD.

The resulting RTD design will use existing TMD hardware by incorporating the 12,500 TMD-GBR Dem/Val Solid-state Transmit/Receive modules into the RTD antenna (50% of the total requirement). Additionally, the RTD will reconfigure and utilize the existing TMD-GBR's Cooling Equipment Unit (CEU), Operator Control Unit (OCU), and Electronic Equipment Unit (EEU).

Although the NMD and TMD missions differ significantly, the EKV program will leverage off of TMD technology developments to the maximum extent practical. Stressing challenges that are similar in both NMD and TMD include issues such as on board sensor fusion, BM/C^3 interfaces, logistical support, wafer scale integration electronics, and producibility of certain subcomponents such as Inertial Measurement Units (IMUs).

NMD BM/C^3 is functionally similar to the TMD BM/C^3 in terms of information architecture, situational assessment, and battery level engagement operations. Both BM/C^3 batteries interface with the command level BM/C^3 and perform integrated battery engagement operations. The NMD BM/C^3 battery will leverage off the TMD firing battery concept.

Acquisition streamlining techniques developed for TMD programs will be considered for application in reducing deployment lead times for a possible NMD deployment.

3.5 Cost of a Single, ABM Treaty Compliant Site

As required, this report is to provide the additional funding required and the additional time required after FY 1999 in order for initial deployment of a limited, ABM Treaty compliant capability at a single site.

The NMD Technology Readiness Program, based on an average of $600M per year during FY 1995-1999, will develop element technology along a path leading to a demonstration of an integrated system of the objective architecture. As these elements and associated technologies are developed, deployment opportunities will become available. To determine deployment costs of a single site, ABM Treaty compliant system, the following assumptions were made about when a decision to deploy is made, the urgency of deployment, maturity of the element and applicable technology, and a required level of system performance.

(1) Decision to deploy is made at the end of FY 1999

(2) The technical progress expected to be made during FY 1995-1999 is actually achieved

(3) Need to deploy is urgent, and time to deploy a limited initial capability is the key measure of merit

The deployable system will consist of those elements and technologies that have successfully completed planned development activities by the end of FY 1999. Urgency will be reflected in waivers to specifications, testing requirements or procurement procedures, all in the interest of saving time. Development, testing, and production will be concurrent. It is estimated that deployment of a crisis capability could be completed in less than three years (but could take as long as five years depending on the degree of streamlining allowed) from the decision to proceed. Estimated costs are $6-8B for FY 2000-2004. This deployment option consists of a single ABM Treaty compliant site at Grand Forks with 20 interceptors and a ground based radar (available FY 2002-2003), block 2 of BM/C^3, DSP satellites, and a constellation of 18 SMTS satellites with medium wavelength infrared sensors (available FY 2003-2004). The defense system will be the mid term option described earlier in Section 3.2.3. The threat capability is also described.

3.6 Program Alternatives

In addition to describing the current LDS development plan, and addressing the added cost and time required to deploy an initial NMD capability assuming the currently planned $600M per year from FY 1995-1999, the FY 1994 National Defense Authorization Act also requested that the Department address two alternative FYDP funding assumptions, $750M per year and $450M per year from FY 1995-1999.

3.6.1 Averaging $750M Per Year

The funding level of $750M per year during FY 1995-1999 would provide three advantages: (1) reduced risk levels, (2) increased defense system capability, and (3) shorter development and deployment times.

The funds would primarily be allocated to EKV research and development to increase testing to minimize risks. This will allow the continuation of a second contractor throughout FY 1995-2000. Since the first opportunity to fly a complete kill vehicle prototype against a representative threat target occurs late in FY 1997, a second technical approach using another contractor would greatly reduce risk. This risk reduction is particularly critical prior to demonstrating an integrated interceptor (EKV and booster) with other sensors and BM/C^3 for the objective system.

Significant additional funding would also be provided for the SMTS to accelerate the LWIR ground testing, and schedule for the development of an LWIR capable SMTS. This would lead to the inclusion of the LWIR SMTS as part of the contingency deployment architecture at the end of FY 1999. The LWIR SMTS would be available for deployment around 2005.

A reduction in deployment time is primarily due to conducting tests during technology development that would have been deferred until after a decision to deploy was made. In addition, deployment time will be further reduced due to increased effort expended on deployment planning activities. It is estimated one year is saved in development time by doing the above activities.

Technology insertion efforts would be at reasonable levels insuring the infusion of the appropriate technology which would provide increasing system capabilities.

In summary, the program under this funding level would achieve the following: (1) accelerated development by approximately one year, (2) reduced system performance risk, and (3) reduced deployment time by approximately one year.

3.6.2 Average $450M Per Year

This funding level could seriously damage our NMD readiness strategy and would likely permit projected third world threats to the homeland to materialize prior to any viable NMD deployment capability. At this low investment rate, the overall NMD development cost significantly increases as does the time required to develop and deploy the capability needed to overcome existing ballistic missile threats.

The EKV program is the most critical of the technology long poles and would remain top priority within this very limited funding. However, funding for the EKV program would need to be reduced in order to be consistent with a stretched out schedule for development of the other elements of an objective NMD system. This would increase EKV development costs. The SMTS program is undergoing a process to down select from two to one contractor based on criteria to first develop a sensor to view relatively warm targets and later a sensor to view more stressing colder targets. Reduced funding could put into jeopardy the strategy upon which the down select process was based as well as increase schedule and costs for SMTS. The radar technology demonstration would experience delays in hardware purchases that would increase overall costs due to not being able to take advantage of TMD production runs of transmit/receive modules; one of the basic components of the radar.

In summary, the reduced for EKV, SMTS, and GBR projects would result in delays and increased costs compared to a $600M per year funding level. The overall delay in development of the objective system capability (as opposed to a crisis capability) would be at least two years and the increased costs in deployment of an initial ABM treaty compliant site could be about $1.3B. There will be very limited effort on system integration and technology insertion, and almost no effort in deployment readiness planning. These efforts are critical in addressing key systems issues such as element integration, and they are essential to being able to reduce deployment lead times.

Chapter 4

Advanced Technology Development Strategy And Programs

Chapter 4
Advanced Technology Development Strategy And Programs

4.1 Technology Investment Strategy

The BMDO strategy for investing in technology development takes the philosophy that while we shift the focus and vision of Ballistic Missile Defense (BMD) to acquiring Theater Missile Defense (TMD) systems that meet today's requirements, we would be shortsighted to forget potential future requirements and the technology needs of tomorrow. Accordingly, these BMDO efforts concentrate on affordable, high payoff technologies that can:

- Enable and assure the continuing vitality and potential improved performance and affordability of the deployed TMD system;
- Demonstrate the technology base to defend against advanced threats such as chemical and biological warheads, early release submunitions and nuclear weapons;
- Offer alternate system approaches that can provide major increases in TMD and NMD capability against an evolving threat and are achievable within 15 years.

In essence, we are developing the technology that is essential to meeting the BMDO mission.

In keeping with Congressional direction contained in the FY 1994 National Defense Authorization Act, several BMDO managed technology programs directed towards far term ballistic missile defense have been transferred from BMDO management. A discussion of the programs transferred is summarized in Chapter 5 of this report.

4.2 Technology Needs

To maintain the vitality of a BMD architecture over time, technologies being developed must provide options for improvements to deployed defenses that evolve and/or replace those deployments with new capabilities to respond to a range of needs. Among the most important of these needs are capabilities to:

- Meet straightforward countermeasures such as proliferation of defense aim points by creating a debris cloud by purposefully breaking up the spent booster of the Theater Ballistic Missile (TBM);
- Cope with threat evolution such as advanced submunitions that improve the effectiveness of the attacking missile, longer range missiles that enlarge the areas that can be attacked, and increasing the target complexes that must be defended; and

- Handle a proliferation of ballistic missiles and an increasing number of countries possessing them. This greatly expands the potential battle space, increases the potential for surprise, and leads to the need for rapid deployment of TMD to counter rapid escalation of a conflict.

To prepare to meet these future needs, the BMDO is investing in the high leverage technologies that can provide:

- Boost phase intercept that can defeat proliferation, tactics, and warhead deployments designed to saturate midcourse and terminal tier defenses,

- Continuous coverage, that defends against surprise attack or during the early stages of rapidly escalating conflicts,

- Exo- and endoatmospheric intercept with high probability of kill at lower cost, thus expanding battle space, enlarging defended areas and overcoming simple countermeasures,

- Multi-sensor detection and tracking that extends through the missile flight path, and

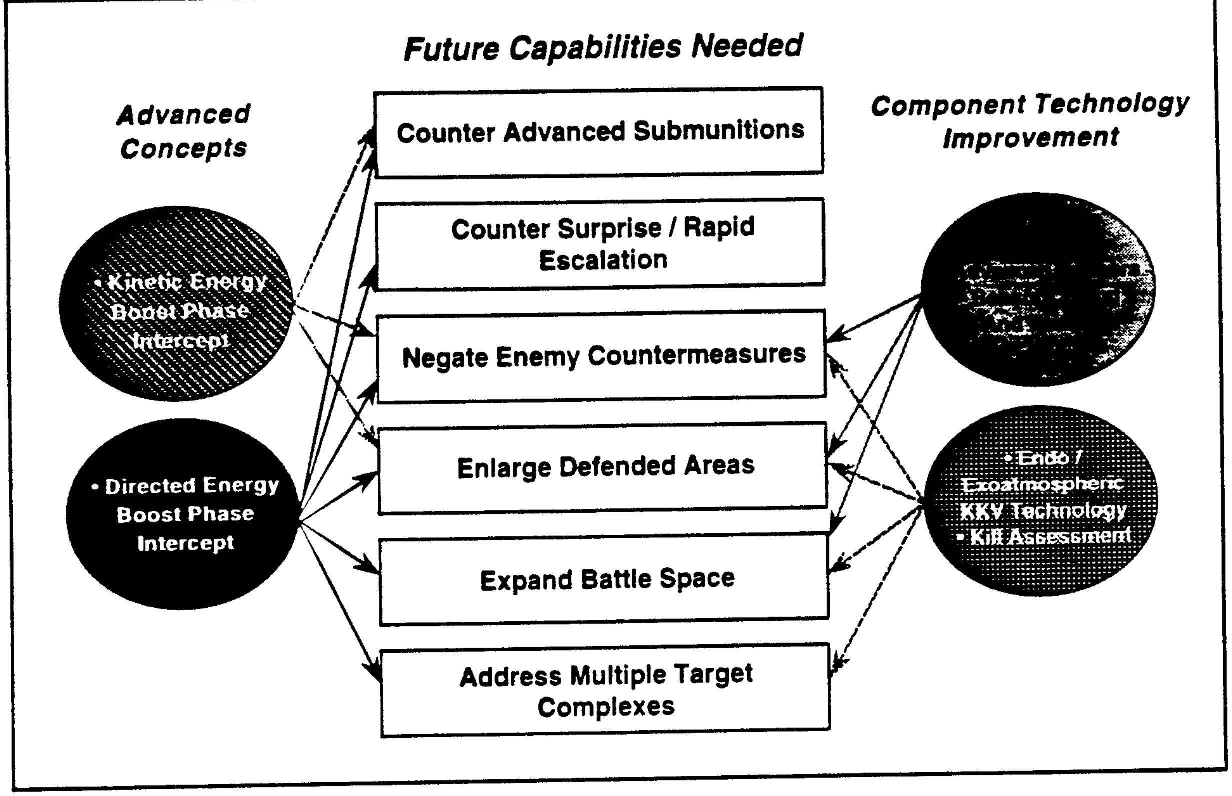
- Identification and discrimination that can support early assured targeting.

Figure 4-1 diagrams the future threat in terms of capabilities needed and potential technology solutions. Arrows point from each critical technology solution to the mission needs which that solution addresses.

Many of these future mission needs can be met with boost phase intercept weapons and their associated and/or integral acquisition and tracking systems. Early boost phase intercept is a powerful deterrent since debris from the intercept falls back near the attacker far from defended territory. This could serve as a powerful deterrent against further development and proliferation, or actual use of chemical, biological, or nuclear warheads. Furthermore, as the range of ballistic missile threats increase and types of warheads proliferate, the importance of boost phase intercept increases dramatically. Intercept in the boost phase near the point of launch of the attack provides large defended areas and simplifies the identification and discrimination problems brought on by multiple warheads and simple penetration aids, thus allowing more affordable defenses. Additionally, boost phase intercept can concentrate on aggressor launch sites rather than coordinating large numbers of terminal defenses with limited coverage deployed to defend the increased numbers of potential targets brought under attack.

Space Based Lasers (SBL) cover the widest spectrum of anticipated mission needs. Such weapons would be equipped with highly capable Acquisition, Tracking, Pointing and Fire Control (ATP-FC) systems. The SBL-ATP system can acquire, track and point the high energy beam over thou-

Figure 4-1. Technology Needs



sands of kilometers of space to a meter or less accuracy, image the target using a Laser Detection And Ranging (LADAR) to support identification and discrimination, and destroy thrusting missiles very early in their boost phase (≈35,000 ft). The space based laser is the only major U.S. technology under development that can provide global, 24 hour, early boost phase intercept of both theater and strategic ballistic missiles. Analyses of these concepts have shown the SBL to be the most capable boost phase intercept system, able to provide outstanding, cost effective performance in both theater and national missile defense. The BMDO Directed Energy Program contains most of this Nation's High Energy Laser (HEL) research and development effort, and is providing advanced technologies to emerging HEL programs in the Navy, Army and Air Force.

Kinetic energy weapons launched from manned and unmanned aircraft, using advanced, high-speed boosters equipped with hit-to-kill interceptors, are another, potentially nearer term boost phase intercept technology. A Boost Phase Intercept (BPI) system consists of an off board sensor to provide launch detection and early track of a threat Theater Ballistic Missile (TBM). The track file generated from this platform is then transmitted through a tactical data network such as JTIDS to a launch platform flying in theater. The BPI missile can engage anywhere in the target's ascent, whether in boost phase or after booster burnout during the longer ascent phase, but the latter fails to negate the very important advanced submunition threat. The requirement for a BPI capability has been codified by a formal Operational Requirements Document (ORD). Air launched kinetic energy weapons have the potential to provide an early initial U.S. capability of boost phase intercept.

Interceptor technology includes exo- and endoatmospheric interceptors with high probability of kill at lower cost, that also expands the battle space, enlarges defended areas, and overcomes simple countermeasures. The Interceptor Technology program develops advanced technology components for kinetic energy weapons for incorporation into current or future interceptors. These include high performance, low cost seekers, avionics, inertial units, divert control, fire control and axial propulsion hardware. Advanced liquid fueled thrust-on-demand propulsion technology has potential to achieve very high velocity with a lightweight (under 50 lbs.) missile. Miniaturized electro-optical sensors will acquire the TBM target and provide terminal homing during the boost phase of the missile flight. These propulsion and guidance subsystems incorporate technologies previously developed for Lightweight Exoatmospheric Advanced Projectile (LEAP) and Brilliant Pebbles, and other Service air-to-air missile programs. These components are integrated and demonstrated in high performance miniature interceptors for exo- and endoatmospheric operations.

The Sensor Technology program plans and executes research and development in areas of phenomenology, discrimination and sensors to support increasingly effective ballistic missile defense systems. The program develops components and demonstrates integration of these components into validated sensors subsystem hardware. BMDO's sensor program ensures that there is a phenomenology data base which includes natural/nuclear backgrounds for plumes and midcourse targets. It includes both active (laser and radar) and passive (infrared focal plane and cryocooler) sensor technology. The sensor technology program will ensure the ability to have multi-sensor detection and tracking capabilities that extend through the missile flight path, and the discrimination and identification to support assured targeting.

4.3 Program Overview

Figure 4-2 summarizes the current advanced technology plan. The program is structured in three major segments - Kinetic Energy Ascent/Boost Phase Intercept, Directed Energy Boost Phase Intercept, and Advanced Sensor Technology.

4.3.1 Kinetic Energy Boost Phase Intercept (BPI)

This program is geared to develop and test (through demonstrations) component technologies which directly support evolving airborne BPI concepts for the Air Force and the Navy. Manned and unmanned weapon system and off board sensor concepts are being pursued with emphasis on fighter aircraft concept demonstrations. Technology efforts will be focused on endoatmospheric interceptors with backup post boost phase intercept capability, missile propulsion to achieve high velocity flight profiles, platform integration and surveillance/sensor cueing.

The funding for this program is to advance and demonstrate focused technologies relevant to intercepting Theater Ballistic Missiles (TBM). Proof-of-principle hit-to-kill demonstrations are planned to validate the maturity of the technology to proceed into acquisition later in the decade. High velocity interceptor missiles with kinetic kill capability will be flown on manned and unmanned aircraft according to evolving Air Force and Navy requirements. The plan is to perform sufficient BPI demonstrations to warrant entering selected concepts into acquisition as early as FY 1998. Preliminary program planning has commenced with the Services.

Figure 4-2. Advanced Technology Schedule

	FY 94	FY 95	FY 96	FY 97	FY 98	FY 99
Kinetic Energy Boost Phase Intercept	Navy LEAP Test Legacy	BPI Requirement Definition	BPI KKV Ground Tests	Aircraft Mods	Airborne BPI Demo Flight	
Directed Energy Boost Phase Intercept	ALI Facility Beneficial Occupancy	HABE Balloon Hi Alt Checkout ALI Hardware On Bench	ALI Subsystem Testing HABE Passive Experiment Flights ALI Hi Power Tests	HABE Active Experiment Flight DE Integrated Experiment PDR	HABE Aim Point Experiment Flight DE Integrated Experiment CDR / Begin Fabrication	
Advanced Sensor Technology	MWIR BTH Track Experiment	Folded CO_2 LADAR Demo	On Sensor Compression Demo Optical Active / Passive Algorithm Demo	Adaptive Sensor Airborne Demo Sensor Fusion Lab Demo	Fused LADAR / Passive Tech Demo	Fused LADAR / Passive / RF Tech Demo Active / Passive / RF Aircraft Integration

The focus of the BPI effort will be to integrate existing operational and technology programs into a technology demonstration. The objective is to demonstrate the requisite technologies in a real time operation at a scale size adequate to clearly establish operational utility and system integrity. The demonstration is envisioned to culminate with operationally representative boost phase intercepts in 1998.

4.3.2 Directed Energy Boost Phase Intercept

This program continues the process of integrating high-power chemical laser components and technologies developed over the past 10 years specifically for the boost phase intercept mission. In the Alpha Lamp Integration (ALI) experiment, the existing megawatt class Alpha laser, the 4 meter LAMP primary mirror, and beam alignment and control technologies are being integrated for a ground demonstration of a complete high energy laser beam train. The Alpha program will complete testing in FY 1995 and transfer the laser to the ALI integration experiment. ALI will begin high-power testing in mid FY 1996. While not in a fully operational system configuration, ALI will demonstrate the integrated performance of near full scale SBL subsystems. ALI subsystems are, in fact, fully scalable and traceable to those required to destroy ballistic missiles during their vulnerable boost phase, prior to their ability to deploy multiple chemical, biological, or nuclear munitions.

Demonstration of all key, Acquisition, Tracking, Pointing and Fire Control (ATP-FC) technologies, added to the accomplishments of ALI, completes technologies required for space laser boost phase intercept. These efforts demonstrate the required critical functions for all candidate Directed Energy Weapons (DEW). These functions include acquiring, identifying, and prioritizing the targets to be engaged, precision tracking of each target, selecting and establishing the line-of-sight to the target aim point, holding the beam on the aim point, assessing the results, and reinitiating the sequence to engage a new target.

The ATP-FC program has three major thrusts: (1) component technology development; (2) field tests of integrated components, and; (3) definition of ATP-FC concepts with proof-of-principle testing of components that meet operational requirements. Component technology efforts are currently focused on demonstrating the high precision, inertial reference unit and the laser illuminator needed for ATP. These components, in turn, support the field tests conducted as part of the High Altitude Balloon Experiment (HABE). A series of field experiments with payloads on high altitude balloon platforms will obtain critically needed phenomenology data and build upon technology base products to demonstrate all the tracking and functional integration needed to control single target engagements. The Advanced DEW Active Precision Tracker (ADAPT) program provides the concept definition efforts. ADAPT addresses the major tracking and pointing component performance requirements and develops technologies for advanced ATP-FC.

In the near term, the ATP program will develop the component technology and the flight hardware and that will be integrated in the HABE flights. From an altitude of 85,000 feet, the HABE integrated ATP system will passively track missiles throughout the boost phase in FY 1996 and actively track them in FY 1997. Following the fabrication of HABE hardware and software, the ATP technology program will refocus on developing an operationally configured ATP subsystem, defined under the ADAPT program.

Together, ALI and ATP successes will lead to a start on an operationally configured, fully integrated ground demonstration of a high energy laser system with a planned Preliminary Design Review (PDR) in FY 1997 and a Critical Design Review (CDR) in FY 1999. Construction of a new facility to support this demonstration will begin in FY 1997 at a site yet to be determined.

In parallel, a number of efforts are developing additional promising HEL technologies with the potential for significant cost, weight, and/or brightness improvement. They include uncooled optics which provide significant weight reductions over conventionally cooled high-power optics, shorter wavelength lasers which allow higher brightness systems or the use of a smaller diameter beam director mirror, maintenance of beam quality with molecular rather than mechanical methods, and producibility improvements and decreased costs for large optics manufacturing.

4.3.3 Advanced Sensor Technology

This program is an evolutionary effort to improve below the horizon tracking of ballistic missiles early in their trajectory, improve interceptor seekers, and advance signal processing techniques for efficient and definitive identification and discrimination. Development efforts will provide an early emphasis on compact, adaptable, efficient passive Focal Plane Arrays (FPA) and precision active optical ranger/illuminators. Integrated detection/signal processing demonstrations are scheduled for FY 1996.

Thereafter, the program develops the next generation of sensing technology. Radar development efforts will emphasize miniaturized, adaptive radar techniques. Resources will also be used to develop multi-sensor data fusion and discrimination. Intermediate milestones address a building block approach of the system hardware and algorithm developments. Airborne testing of these integrated technologies will begin in FY 1997. The ultimate objective will be achieved in a FY 1999 aircraft flight that will demonstrate fusion of sensor data from radar, Laser Detection And Ranging (LADAR), and LWIR sensor with on board signal processing, tracking, and discrimination algorithms.

4.4 Innovative Science and Technology (IS&T)

The IS&T program is structured to make unique contributions to BMD by pursuing speculative, high risk technologies that may enable a quantum leap in capability over that available from conventional approaches. The IS&T program has two major thrusts. It conducts an applied research program to provide seed funding to promising technologies and transition those technologies into advanced technology demonstrators. In addition, it provides a means of transferring technology to the private sector.

4.5 Technology Transfer and Dual Use

Much of the RDT&E pursued by the BMDO has broad application to meeting overall DoD needs and potential for civil and civilian applications. A second important objective is, therefore, to conduct a portion of the BMDO RDT&E efforts in a manner that enhances this technology transfer. For eight years, the Office of Technology Applications (OTA) within BMDO has focused on moving BMD technology out of the DoD and other Federal Laboratories and into the commercial marketplace and other agencies. It has been a model program, working closely with government, universities, and industry. To date, the OTA program has observed that 23 spinoff companies, 114 new products, 155 patents, 125 ventures, and 7 cooperative research and development agreements are transferring BMD technology to civilian use.

Activities of BMDO's Small Business Innovative Research (SBIR) are a case in point. In FY 1993, eight small firms with missile defense technology as their centerpiece raised nearly $100 million of new capital in the marketplace. The BMDO investment in these firms through the SBIR program totalled $12 million. Their current inferred valuation is over $500 million. Figure 4-3 lists BMDO RDT&E accomplishments and their dual use potential.

4.6 Significant Accomplishments In 1993

Some advanced technology accomplishments for 1993 are briefly highlighted. These accomplishments are representative of BMDO's advanced technology program and illustrate the broad spectrum of activities required to support TMD.

The RAPTOR/TALON Program, which has recently been transferred from BMDO management, has the objective of demonstrating critical technologies for an unmanned airborne weapon system providing a boost phase intercept capability. During the initial flight test program of the Responsive Aircraft Program For Theater Operations (RAPTOR) piston engine driven Unmanned Aerial

Figure 4-3. BMDO RDT&E Accomplishments

Research Area And Accomplishments	Impact On BMDO Capabilities	Potential Military And Civilian Applications
Rocket Propulsion • Miniaturization Thrust-On Demand Pumped Propulsion Subsystem	• Boost Phase Kill Capability From Airborne Platforms Enabled With Agile, Lightweight Interceptor	• Highly Agile Missiles For Air Warfare And Other Applications
Sensors • 256 x 256 HgCdTe Focal Planes Manufacturable; 256 x 256 InSb Focal Planes And Cryocooler Integrated With Camera; Four New Detector Types • Hunter's Trophy Underground Nuclear Test	• High Quality /Resolution Detection Of Burning Rocket Engines (With 1 Meter Aperature On Ground Can Detect Small Rockets At 2,000 km); Major Weight And Cost Reductions Achieved • Nuclear Hardness Of Various Sensor Components Demonstrated As Near To Meeting BMD System Needs	• Wide Range Of Civil Uses; InSb/Camera Application Now On Commercial Market; Capability And Cost Of Infrared Detection Revolutionalized In Civilian Market (Home Protection, Environmental Monitoring, etc.) • Nuclear Hardened Sensor Components Have Wide Applicability DoD
Electronics • Artificial Diamonds, Thin Film Diamond Coatings	• Optically Transmissive, Heat Resistant Windows For High Velocity, Endoatmospheric Interceptor Guidance Systems; Radiation Harden, Rugged High Performance Semiconductors	• Fostering A New U.S. Industry With Potential $500 Billion Market; Thin Film Diamond Coatings For Cutting Tools And Bearings That Are Virtually Indestructible
Computers • WASP - A Complete Computer On A 4-inch Silicon Wafer • Artificial Neural Network (With NASA Jet Propulsion Laboratories)	• High-speed, Naturally Reconfigurable, Fault Tolerant Processors • High-speed Image Recognition, Multiple Target Tracking Weapon Control, Target Assignment, etc.	• Lighter Weight, Enhanced Capability And Reliability For NASA And Commercial Spacecraft
Communications • Highly Jam Resistant, Lightweight Transceiver, 1 Gigabit Laser Comm	• Jam Resistant, High Data Rate Satellite Downlinks And Cross-links For BM/C^3	• Beam Steering Techniques Applied To Medical Radiation Equipment; AWACS To AWACS Rapid Data Downloading At Station Changes
Power • A Solar Cell Technologies Space Qualified; 30 Percent, Efficiencies (3X Current Cells)	• Cheaper, More Efficient Solar Power For Space Elements Of BMD	• DoD, NASA, NOAA, Civilian Satellite Applications
Lethality • Lethality Of Kinetic And Directed Energy Weapons	• Fundamental To Weapon Designs	• Methodology And Data Applicable To Other DoD Weapons
Materials • Carbon-carbon Process Time Cut By 90%	• Halves Cost Of Missile And Rocket Components	• Widely Applicable
High Energy Laser Devices • Multi-megawatt Laser Successfully Tested In Lightweight Space Configuration • Incorporates Advanced Optics With Ultra-high Reflectivity Coatings	• Demonstrated Practical Design For High-power Space Configured Weapon Laser For Boost Phase Target Kill • Highly Loaded Optics Require No Cooling, Reduces Weight And Cost	• Potential For Other Space Laser Missions, e.g. Counter-air • Simplified Optics Designs For Commercial Lasers
Acquisition, Tracking And Pointing (ATP) • Inertial Reference For Pointing Accuracies Of Tens Of µrad; Active Vibration Control In Large Space Structures • Efficient Diode Pumped Solid-state Laser Demonstrated	• Major Components Of A Nanorandian Class ATP Subsystem For Space Based Tracking And Pointing Across Ranges Of Thousands Of Kilometers Shown Feasible • Capability For Target Illumination, Imaging And Tracking At Thousands Of Kilometers	• Highly Stable, Vibration Free Line-Of-Sight Control For Space Based Sensors High Precisions, High Resolution, DoD • And Civil Imaging And Surveillance Applications X-ray Lithography, Environmental • Monitoring Using Solid-state Laser
Advanced Optics • Corrected Atmospheric Distortion By Laser Beams Wth High Bandwidth Active Optics • Large (4m) Lightweight Segmented Active Optics Demonstrated • Developed Diamond Turning Process For Manufacturing Nonspherical Optics	• Improves Feasibility Of Ground Based Or Airborne Laser Weapons • Fabricated And Tested Optics For Focusing And Projecting High-power Space Laser Weapon Beam • Orders Of Magnitude Reduction In Cost For Laser Device Optics	• Increased Resolution For Space Surveillance From Ground, Enabling Ground Based Atmospheric Telescopes With Near Diffraction Limited Performance • Makes Possible Very Large Segmented Astronomical Telescopes-Space Or Ground • Commercial Manufacture Of Large Optical Components

Vehicle (UAV), it flew 17 successful missions validating flight control and navigation subsystem performance. The modified four-cylinder piston engine that powers the aircraft has also demonstrated high altitude performance in an altitude chamber up to 70,000 feet. The advanced "thrust-on-demand" propulsion subsystem and guidance components for the Tactical Launch On Notice (TALON) missile have been successfully tested in several strap down firings. Performance testing of the miniaturized guidance components has provided confidence that the missile design weight and performance goals can be met. A free flight rocket launch is planned for 1994 (ASTRID I experiment).

The Lightweight Exoatmospheric Projectile (LEAP) program advanced integrated interceptor technologies to provide risk reduction for systems that could be deployed prior to the beginning of the twenty-first century. LEAP technology insertion demonstrations using Navy STANDARD missile systems continued with a successful flight test that validated a modified removable shroud, ejection of an inert kinetic kill vehicle, improved ship system fire control modifications, and missile flight environments. Two high altitude feasibility demonstrations of short-range attack missiles for air-launched LEAP concepts were accomplished using both the B-1B and B-52 aircraft. The LEAP-3 mission was conducted at White Sands Missile Range with a LEAP kinetic kill vehicle acquiring and tracking a warm body ballistic target. Advanced propulsion programs achieved the first full-up static and hover tests of a solid divert interceptor projectile.

As a result of full scale, high resolution sled tests and flight tests, BMDO analyzed the test data and published the baseline lethality criteria for kinetic energy weapons, which established the baseline for engagement conditions necessary for specified levels of kill of the threat ballistic missile warheads.

The maiden flight of the Single Stage Rocket Technology (SSRT) Delta Clipper Experimental (DC-X) was successfully executed after less than two years and $60 million in development. Subsequent flights of the DC-X expanded the flight envelope to increasing altitudes and flight durations. These successes demonstrated the application of current technology to resolution of high cost space launch through a single stage reusable rocket system designed around a minimal operating crew and maintenance requirements. The DC-X has been transferred to the Advanced Research Projects Agency (ARPA) for continued development.

Long-lived spaceflight compatible cryogenic coolers have been developed for low temperature infrared sensor operations. A cooling capability to 60 degrees Kelvin was achieved with a 95% reliability design for an expected lifetime of over 10 years. Also fabricated and demonstrated was a miniature, single stage turbine cooler operating at temperatures as low as 35 degrees Kelvin for increased long infrared sensor performance. Very long wave infrared sensor arrays operating out to 26 micrometers were fabricated and achieved nearly noise free gain, allowing for detection, tracking and discrimination of very cold targets as well as increased range for standard warheads.

Integration and reproducible operation of the megawatt-class Alpha high-power laser with a high-power beam control system and four-meter transmitting telescope continued with demonstration of an uncooled, lightweight silicon mirror internal to the resonator. Uncooled optics with very low absorptance coatings significantly decreased system's weight and complexity, and eliminated the major source of beam jitter. Optical component temperature increases were demonstrated to be less than a degree during five high-powered laser tests. Surface diffraction gratings used for sampling the outgoing wavefront on the center segment of the segmented four-meter-diameter transmitting telescope primary mirror were tested and significantly surpassed specifications. Likewise, uncooled single-crystal silicon optics for the fast-steering mirror and the diagnostic telescope assembly's secondary mirror produced similar high performance results. Fabrication of a lightweight, space compatible four-meter segment of an 11-meter-class beam expander telescope's segmented primary mirror has been completed. The center segment has been formed, shaped, and ground, and is ready for final polishing. Four uncooled waxicon inner-cone size test articles were fabricated as replica optics for an uncooled resonator, and have demonstrated an 0.8-2.0 nanometer roughness figure, meeting the requirements for a totally uncooled resonator. This technology also provides a growth path to still brighter systems.

The Space Integrated Controls Experiment (SPICE) completed a closed loop demonstration of active control of structural disturbances in a large, lightweight space structure. Jitter rejection ratios of 65:1 (ratio of base disturbance input to optical line-of-sight jitter) were achieved. Previous state-of-the-art rejection ratio was 10:1 in any structural control experiment. The two axis Inertial Pseudo-Star Reference Unit (IPSRU) has been fabricated, assembled and tested, completing a major step in demonstrating a high accuracy, three axis, flight qualifiable inertial reference unit that will be used for ATP experiments. As an inertially stabilized platform coupled with an active servo system, the small lightweight reference unit can account for and reduce line-of-sight pointing errors in optical imaging systems. It has demonstrated stabilization to less than 100 nanoradians.

With an eye to the future when new technologies must replace today's technologies, BMDO invested in research to find what is possible, mixing basic research with technology demonstrations. Such research aims at shrinking the weight, power, and volume of antimissile technology, at sensors that leapfrog the state-of-the-art in detecting hostile missiles, and at materials with entirely new capabilities. In most cases these technologies will also open new possibilities for commercial dual use purposes.

Chapter 5
Program Elements Descriptions And Funding

5.1 Introduction

This section provides details regarding the funding of BMDO sponsored programs and projects. The information is presented by funding Program Element (PE) and by project and program.

For FY 1994 five major program elements are used to integrate the ballistic missile defense research and development efforts. For FY 1995, in response to the refocused priorities defined through the Bottom-Up Review, eight major program elements are used. Two additional program elements provide ballistic missile defense procurement and construction funding.

The single Theater Missile Defense program element, PE 0603216C, has been expanded to three program elements: PE 0603216C which includes activities pertaining to advanced technology development efforts; PE 0604216C which includes activities pertaining to systems design and demonstration; and PE 0604225C which includes activities leading to finalizing designs and validating manufacturing and production processes.

The Limited Defense System (PE 0603215C), Other Follow-on Systems (PE 0603217C), and Spaced Based Interceptors (PE 0603214C) program elements have been consolidated into Ballistic Missile Defense PEs corresponding to program development phase. PE 0603217C includes those activities pertaining to ballistic missile defense advanced technology development; PE 0604217C includes those activities pertaining to demonstrating and validating technologies capable of supporting ballistic missile defense; and PE 0605217C includes those activities pertaining to finalizing designs and validating manufacturing and production processes for technologies supporting ballistic missile defense.

The Research and Support Activities program element (PE 0603218C), which included three categories of activities: Research, General Test and Evaluation, and Program Support, is now limited to include only activities specifically associated with the oversight and management of ballistic missile defense systems RDT&E.

Figure 5-1 summarizes the FY 1994 and the current program element descriptions.

Figure 5-1.Program Element (PE) Descriptions

FY 1994 Program Elements	Current Program Elements
PE 0603216C: Theater Missile Defense which included programs, projects, and activities (and supporting programs, projects, and activities) which have as a primary objective the development of deployable and rapidly relocatable advanced theater missile systems.	**PE 0603216C:** Theater Missile Defense (Advanced Technology Development) which in-cludes programs, projects, and activities that have as a primary objective the development of technologies capable of supporting systems, components, and architectures that could produce highly effective defenses against theater missile threats. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs. **PE 0604216C:** Theater Missile Defense (Demostration and Validation) which includes programs, projects, and activities that have an objective of system design and demonstration of the critical processes and technologies (early prototype) required for systems that are capable of providing a highly effective defense against theater missile threats. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs. **PE 0604225C:** Theater Missile Defense (Engineering and Manufacturing Development) which includes programs, projects and activities that have an objective to mature and finalize selected system designs, validate manufacturing and production process, test and evaluate systems that are capable of providing a highly effective defense against theater missile threats. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs.
PE 0603215C: Limited Defense System which included programs, projects, and activities (and supporting programs, projects, and activities) which have as a primary objective the development of systems, components, and architectures for a deployable antiballistic missile system that is capable of providing a highly effective defense of the United States against limited ballistic missile threats, including accidental or unauthorized launches or third world country attacks.	**PE 0603217C:** Ballistic Missile Defense (Advanced Technology Development) which includes programs, projects, and activities that have as a primary objective the development of technologies capable of supporting systems, components, and architectures that could produce highly effective defenses. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs.

Chapter 5

Program Elements Descriptions And Funding

Figure 5-1.(Cont'd) Program Element (PE) Descriptions

FY 1994 Program Elements	Current Program Elements
PE 0603214C: Space Based Interceptors which included programs, projects, and activities which have as a primary objective the conduct of research on space based, kinetic kill interceptors, such as Brilliant Pebbles, that could provide an overlay to ground based ABM interceptors.	**PE 0604217C:** Ballistic Missile Defense (Demonstration And Validation which includes programs, projects, and activities that have as a primary objective the development of technologies capable of supporting systems, components, and architectures that could produce highly effective defenses. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs.
PE 0603217C: Other Follow-on Systems which included programs, projects, and activities which have as a primary objective the development of technologies capable of supporting systems, components, and architectures that could produce highly effective defenses in the future.	**PE 0605217C:** Ballistic Missile Defense (Engineering And Manufacturing Development) which includes programs, projects, and activities that have as a primary objective the development of technologies capable of supporting systems, components, and architectures that could produce highly effective defenses. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs.
PE 0603218C: Research And Support Activities which contained three categories of activities: Research; General Test and Evaluation; and Program Support for activities in one or more of the other Program Elements.	**PE 0602217C:** Ballistic Missile Defense (Exploratory Development) which includes programs, projects, and activities that have a primary objective to explore innovative science and engineering and Small Business Innovative Research for technologies of interest to a ballistic missile defense objective. Includes manpower authorizations and the associated costs specifically identified and measured to the performance of these programs.
	PE 0603218C: Ballistic Missile Defense (RDT&E Management Support) which provides for manpower authorizations and the associated costs specifically identified and measured to the oversight and management of ballistic missile defense systems RDT&E.

5.2 Program Element Funding Summary

The key activities funded by each program element and the level of funding planned for each is provided in Figure 5-2. A summary reflecting funding by program and project, including the aggregate of funds provided from previous years, is provided by Figure 5-3.

5.3 BUR Impact on Infrastructure and Support Funding

The extent of testing and simulation infrastructure and the level of engineering and technical analyses has substantially changed as a result of the Bottom-Up Review (BUR) conducted in 1993. The focus of these efforts has also shifted to primarily address Theater Missile Defense (TMD) with National Missile Defense (NMD) activities continuing, albeit at a markedly reduced level.

Project 3101, which is a new project for FY 1994, consolidates Engineering and Integration Support activities previously managed under several separate projects. Overall, these activities were reduced to approximately 30% of the FY 1993 levels and the FY 1994 efforts represent a transition year to focus on TMD.

The Architecture and Systems Analysis efforts managed under Projects 3201, 3202, 3203, 3206, and 3211, although not reduced, have been refocused to TMD. Activities addressing NMD have been reduced nearly 40% from FY 1993 levels and further reductions are planned in FY 1995 and FY 1996.

The Testing and Simulation infrastructure is managed under Project 3300. Activities under this new project, which also consolidates various existing projects into a single project, are reduced nearly 30% from FY 1993 levels.

Finally, contractor consulting services have been reduced from FY 1993 levels. Specifically, FY 1994 Engineering and Technical Services are planned 15% lower than FY 1993 and expected to decline an additional 20% in FY 1995. Overall, total contractor support will decline by 10% in FY 1994 and FY 1995.

5.4 Technology Programs Tranferred From BMDO

Over the past few years, in compliance with Congressional direction and in consonance with the recent Bottom-Up Review findings, the Department of Defense significantly restructured the follow-on technology program for ballistic missile defense. BMDO has identified those programs where transfer to another agency or service is appropriate. In 1993, BMDO (then SDIO) transferred responsibility for management and further development of the Airborne Laser to the Air Force and the Free Electron Laser to the Army. BMDO has proposed that the Single Stage Rocket Technology (SSRT) project be transferred to the Advanced Research Projects Agency and that the TOPAZ Thermionic Space Nuclear Power Technology project and the Miniature Sensor Technology Integration (MSTI) project be transferred to the Air Force. The Clementine residual hardware is being transferred to the Navy with the recommendation that the Services continue to support

Figure 5-2. Program Element Key Activities (In Millions Of Then Year Dollars)

Project Number And Title	FY 1994* Appropriated	FY 1995** Request	FY 1996 Programmed
RDT&E			
PE 0602217C			
Ballistic Missile Defense (Exploratory Development)			
1601 Innovative Science And Technology	42	60	60
1602 Small Business Innovative Research	32	46	47
Total	73	106	107
PE 0603216C			
Theater Missile Defense (Advanced Technology Development)			
1105 Discrimination	4	58	52
1106 Sensor Studies And Experiments	30	29	35
1201 Interceptor Component Technology	8	5	5
1215 Boost Phase / Int / Exo	15	0	0
1216 Sea Based Theater Wide Defense	80	18	31
1501 Survivability	3	5	4
1502 Lethality And Target Hardening	29	33	29
1504 Material And Structures	1	0	0
2209 ACES	61	52	45
2212 Corps SAM	20	18	31
3101 Engineering / Integration Support	13	46	46
3201 Architecture And System Analyses	27	42	48
3202 Operations Interface	0	3	3
3300 Test And Evaluation Support	92	164	168
4000 Operational Support	11	8	18
Total	393	479	514
PE 0603217C			
Ballistic Missile Defense (Advanced Technology Development)			
1101 Passive Sensors	10	25	27
1102 Radar	2	10	9
1104 Signal Processing	7	7	12
1105 Discrimination	54	29	15
1106 Sensor Studies And Experiments	86	49	41
1110 Sensor Integration	25	0	0
1111 Advanced Sensor Technology	37	48	48
1201 Interceptor Component Technology	12	23	29
1204 Interceptor Studies And Analysis	6	0	0
1209 Endoatmospheric Technology	3	0	0
1212 D-2 HVG Projectile	5	0	0
1214 Advanced Interceptor Technology	15	0	0
1215 Boost Phase / Int / Exo	16	61	65
1217 KKV Technology	57	120	113

Figure 5-2. (Cont'd) Program Element Key Activities (In Millions Of Then Year Dollars)

Project Number And Title	FY 1994* Appropriated	FY 1995** Request	FY 1996 Programmed
<u>RDT&E</u> (Cont'd)			
PE 0603217C			
Ballistic Missile Defense (Advanced Technology Development)			
1302 Chemical Laser	54	78	78
1303 Neutral Particle Beam	7	0	0
1305 ATP / FC	6	13	13
1307 Directed Energy Demonstration	2	0	0
1403 Computer Engineering	0	3	0
1405 Communications Engineering	2	1	0
1501 Survivability	3	3	3
1502 Lethality And Target Hardening	1	0	0
1503 Power And Power Conditioning	7	10	10
1504 Material And Structures	6	7	11
1700 Flight Test / Launch Activities	43	0	0
2104 GBR	25	8	11
2300 BM/C^3 Technology	23	57	59
3101 Engineering / Integration Support	29	19	19
3107 Environment, Siting And Facilities	6	6	6
3201 Architecture And System Analyses	11	8	8
3202 Operations Interface	4	2	2
3203 Intelligence Threat Development	8	8	8
3204 Countermeasures Integration	16	18	18
3206 System Threat	7	7	7
3300 Test And Evaluation Support	187	103	83
4000 Operational Support	43	48	48
4302 Technology Transfer	3	3	3
Total	829	770	743
PE 0604216C			
Theater Missile Defense (Demonstration And Validation)			
2104 GBR	234	173	157
2207 PATRIOT	81	69	31
2208 ERINT	97	58	20
2210 THAAD	435	496	457
2213 Sea Based Area TBMD	154	180	240
2308 HAWK System BM/C^3 Modifications	30	27	23
3211 C^{4}I Concepts	13	34	20
3300 Test And Evaluation Support	38	35	38
Total	1,080	1,071	986

Figure 5-2. (Cont'd) Program Element Key Activities (In Millions Of Then Year Dollars)

Project Number And Title	FY 1994* Appropriated	FY 1995** Request	FY 1996 Programmed
RDT&E (Cont'd)			
PE 0604217C			
Ballistic Missile Defense (Demonstration And Validation)			
2102 Space And Missile Tracking System (Formerly Brilliant Eyes)	0	120	150
Total	0	120	150
PE 0604225C			
Theater Missile Defense (Engineering And Manufacturing Development)			
2104 GBR	0	0	10
2207 PATRIOT	42	217	206
3211 C^4 I Concepts	0	1	16
Total	42	218	232
PE 0603218C			
Ballistic Missile Defense (RDT&E Management Support)			
4000 Operational Support	199	215	223
Total	199	215	223
MILCON			
PE 0603218C			
Ballistic Missile Defense			
3107 Environment, Siting And Facilities	3	1	3
Total	3	1	3
Procurement			
PE 0208060C			
Theater Missile Defense			
2207 PATRIOT	121	255	436
2213 Sea Based Area TBMD	0	14	11
2308 HAWK System BM/C^3 Modifications	0	4	5
Total	121	273	452

* FY 1994 Funding Appropriated Into Four Major Program Elements. Column Reflects Realignment To Correspond With Current Program Elements

** President's Budget Request

Figure 5-3. Current Projects Funding Profile (In Millions Of Then Year Dollars)

Project Number And Title	Funds Through FY 1993	FY 1994 Appropriated	FY 1995* Request	FY 1996 Programmed
1101 Passive Sensors	472	10	25	27
1102 Radar	125	2	10	9
1104 Signal Processing	553	7	7	12
1105 Discrimination	1,179	58	88	67
1106 Sensor Studies And Experiments	1,245	116	77	76
1110 Sensor Integration	75	25	0	0
1111 Advanced Sensor Technology	0	37	48	48
1201 Interceptor Component Technology	548	20	28	34
1204 Interceptor Studies And Analysis	670	6	0	0
1209 Endoatmospheric Technology	73	3	0	0
1212 D-2 HVG Projectile	16	5	0	0
1214 Advanced Interceptor Technology	0	15	0	0
1215 Boost Phase Int / Exo	0	31	61	65
1216 Sea Based Theater Wide Defense	0	80	18	31
1217 KKV Technology	0	57	120	113
1302 Chemical Laser	881	54	78	78
1303 Neutral Particle Beam	815	7	0	0
1305 ATP / FC	1,429	6	13	13
1307 Directed Energy Demonstration	21	2	0	0
1403 Computer Engineering	5	0	3	0
1405 Communications Engineering	35	2	1	0
1501 Survivability	581	6	8	7
1502 Lethality And Target Hardening	516	30	33	29
1503 Power And Power Conditioning	527	7	10	10
1504 Material And Structures	184	6	7	11
1601 Innovative Science And Technology	688	42	60	60
1602 Small Business Innovative Research	260	32	46	47
1700 Flight Test / Launch Activities	201	43	0	0
2102 Space And Missile Tracking System (Formerly Brilliant Eyes)	646	0	120	150
2104 GBR	543	259	181	178
2207 PATRIOT	330	244	542	672
2208 ERINT	276	97	58	20
2209 ACES	118	61	52	45

* President's Budget Request

Chapter 6

ABM Treaty Compliance

Figure 5-3. (Cont'd) Current Project Funding Profile (In Millions Of Then Year Dollars)

Project Number And Title	Funds Through FY 1993	FY 1994 Appropriated	FY 1995* Request	FY 1996 Programmed
2210 THAAD	348	435	496	457
2212 Corps SAM	45	20	18	31
2213 Sea Based Area TBMD	65	154	194	252
2300 BM/C³ Technology	776	23	57	59
2308 HAWK System BM/C³ Modifications	0	30	31	28
3101 Engineering / Integration Support	559**	42	65	65
3107 Environment, Siting And Facilities	29	9	7	9
3201 Architecture And System Analyses	200	38	50	56
3202 Operations Interface	45	4	4	4
3203 Intelligence Threat Development	86	8	8	8
3204 Countermeasures Integration	147	16	18	18
3206 System Threat	24	7	7	7
3211 C⁴ I Concepts	23	13	34	36
3300 Test And Evaluation Support	2,553**	316	302	289
4000 Operational Support	1,918	253	271	288
4302 Technology Transfer	10	3	3	3

* President's Budget Request
** Consolidation Of Former Projects

the Clementine space-rated component and flight qualification project. The RAPTOR Unmanned Aerial Vehicle (UAV) program will be transferred to the Defense Aeronautical Reconnaissance Office. Management of the Hypervelocity Gun Projectile project residual assets will be transferred to the Army. BMDO also recommends that Neutral Particle Beam project residual assets be transferred to the Department of Energy. As a result of these transfers, only those programs that either directly support future TMD and NMD system developments, or hold significant promise for advanced BMD systems, remain under the management responsibility of BMDO.

Chapter 6
ABM Treaty Compliance

6.1 Introduction

The 1972 Anti-Ballistic Missile (ABM) Treaty addresses the development, testing, and deployment of ABM systems and components. The Administration reaffirmed the traditional, or the narrow interpretation of the ABM Treaty in a July 13, 1993 letter to Congress. It should be noted that use of the word "research" does not appear in the ABM Treaty and research is not constrained by the treaty. Neither the United States nor the Soviet delegation to the Strategic Arms Limitation Talks (SALT I) negotiations chose to place limitations on research, and the ABM Treaty makes no attempt to do so. The United States has traditionally distinguished "research" from "development" as outlined by then-U.S. delegate Dr. Harold Brown in a 1971 statement to the Soviet SALT I delegation. Research includes, but is not limited to, concept design and laboratory testing. Development follows research and precedes full-scale testing of systems and components designed for actual deployment. Development of a weapon system is usually associated with the construction and field testing of one or more prototypes of the system or its major components. However, the construction of a prototype cannot necessarily be verified by national technical means of verification. Therefore, in large part because of these verification difficulties, the ABM Treaty prohibition on the development of sea based, air based, space based, and mobile land based ABM systems, or components for such systems, applies when a prototype of such a system or its components enters the field testing stage.

6.2 Existing Compliance Process For BMDO

The Department of Defense (DoD) has in place an effective compliance process (established with the SALT I agreements in 1972) under which key offices in DoD are responsible for overseeing BMD compliance with all the United States arms control commitments. Under this process, the Ballistic Missile Defense Organization (BMDO) and DoD components ensure that the implementing program offices adhere to DoD compliance directives and seek guidance from offices charged with oversight responsibility.

Specific responsibilities are assigned by DoD Directive 2060.1, July 31, 1992, "Implementation of, and Compliance With, Arms Control Agreements". The Under Secretary of Defense (Acquisition & Technology), USD(A&T), ensures that all DoD programs are in compliance with the United States arms control obligations. The Service Secretaries, the Chairman of the Joint Chiefs of Staff, and agency directors ensure the internal compliance of their respective organizations. The DoD General Counsel provides advice and assistance with respect to the implementation of the compliance process and interpretation of arms control agreements.

DoD Directive 2060.1 establishes procedures for ensuring the continued compliance of all DoD programs with existing arms control agreements. Under these procedures, questions of interpretation of specific agreements are to be referred to the USD(A&T) for resolution on a case-by-case basis. No project or program which reasonably raises a compliance issue can enter into the testing, prototype construction, or deployment phase without prior clearance from the USD(A&T). If such a compliance issue is in doubt, USD(A&T) approval is sought. In consultation with the office of the DoD General Counsel, Office of the Under Secretary of Defense (Policy), and the Joint Staff, USD(A&T) applies the provisions of the agreements as appropriate. DoD components, including BMDO, certify internal compliance periodically and establish internal procedures and offices to monitor and ensure internal compliance.

In 1985, the United States began discussions with allied governments regarding technical cooperation on BMD research. To date, the United States has concluded bilateral BMD research Memoranda of Understanding (MOU) with the United Kingdom, Germany, Israel, Italy, and Japan. All such agreements will be implemented consistent with the United States' international obligations including the ABM Treaty. The United States has established guidelines to ensure that all exchanges of data and research activities are conducted in full compliance with the ABM Treaty obligations not to transfer to other states ABM systems or components limited by the Treaty, nor to provide technical descriptions or blueprints specially worked out for the construction of such systems or components.

6.3 BMDO Experiments

All BMDO field tests must be approved for ABM Treaty compliance through the DoD compliance review process. The following major programs and experiments, all of which involve field testing, have been approved and are to be conducted during the remainder of FY 1994 and FY 1995: flights throughout FY 1994-1995 in the Airborne Surveillance Test Bed (AST) program, a revision of the Airborne Optical Adjunct project; Navy LEAP (Lightweight Exoatmospheric Projectile) FTV-TD; SRAM (Short Range Attack Missile) LEAP flight tests 3-4; High Altitude Balloon Experiments (HABE); Extended Range Interceptor (ERINT) program flight experiments; the Midcourse Space Experiment (MSX); AEGIS SPY-1 radar and Standard Missile (SM-2 Block IV) modifications; HAWK and AN/TPS-59 radar upgrades; Skipper; RAPTOR Unmanned Aerial Vehicle (UAV) D-1 platform testing; the Pathfinder Solar Electric aircraft Test Platform (SETP) in the RAPTOR project; Miniature Sensor Technology Integration (MSTI) Satellite Development Program MSTI-3; the Patriot PAC-3 system (with either the Multimode or ERINT missile); Brilliant Eyes Flight Demonstration System (FDS) and the Israeli Arrow interceptor development program known as the Arrow Continuation Experiments (ACES) was provided compliance guidance.

In addition, the following data collection activities continue to be approved: High Altitude Observation aircraft (HALO and ARGUS); Cobra Judy; Godiva; Cobra Ball; TMD Critical Measurements Program (TCMP); Rapid Optical Beam Steering (ROBS) System (formerly called the Transportable LADAR System); Deep Space Program Experiment (Project Clementine Flight I); and Countermeasures Skunkworks flight tests SM 1-3. The following project has been approved but is not funded for FY 1994-1995: Red Tigress III. The System Integration Tests (SITs) planned for the future uses data collected by a variety of sensor systems for simulation and integration planning purposes; follow-on SITs will be examined for Treaty compliance as their experiments are better defined.

The following project has approved activities that are not considered to be in field testing: Alpha/LAMP Integration; and the High Energy Laser System Test Facility (HELSTF) experiments and data collection activities. Also, the National Test Bed including the Experiment Control Center (CERES) has been determined to be compliant with the ABM Treaty.

The following target development projects have been approved: Strategic Target System (STARS); Operational and Developmental Experiments Simulator (ODES); STORM Ballistic Tactical Target Vehicle (BTTV) and Maneuvering Tactical Target Vehicle (MTTV) flights (formerly called the ERINT Target System development project); and the HERA "B" target vehicle. All BMDO launches are reviewed for compliance with the research and development launch provisions of the 1987 Intermediate-Range Nuclear Forces Treaty. Such launches will be notified to the Nuclear Risk Reduction Center of the former Soviet Union as required.

Changes to the above approved experiments and programs are required to be reviewed for compliance implications.

The following programs, some of which have not been sufficiently defined for compliance review, are not yet approved: Navy LEAP FTV 3-4; Short Range Attack Missile (SRAM) LEAP flight tests 5-9; Theater High Altitude Area Defense (THAAD) interceptor; Theater Missile Defense-Ground Based Radar (TMD-GBR); Corps SAM; MSTI-Pave Paws Integration Experiment and the RAF Fylingdales BMEWS Tracking Experiment; Exoatmospheric Kill Vehicle (EKV) early flight tests (FY 1995-1997) (formerly the Ground Based Interceptor): and AWACS EAGLE.

As required by the National Defense Authorization Act for Fiscal Year 1994, DoD submitted ABM Treaty compliance review reports on the following systems: Theater High Altitude Area Defense (THAAD) system; Theater Missile Defense-Ground Based Radar (TMD-GBR); Brilliant Eyes; AEGIS AN/SPY-1 radar, Standard Missile-2 Block IVA; PATRIOT Multimode Missile, and the ERINT missile.

We are planning to develop and deploy theater/tactical missile defense systems to counter the projected threat to our forces abroad and to our allies. Currently the Administration is negotiating in the ABM Treaty Standing Consultative Commission a proposal to clarify the demarcation between ABM and non-ABM systems. The Adminstration's objective is to permit development and deployment of highly effective TMD systems capable of countering the modern tactical ballistic missile threat, consistent with the ABM Treaty's limits on defense against strategic ballistic missiles.

Chapter 7

International Coordination And Consultation

Chapter 7
International Coordination And Consultation

7.1 Introduction

To address the security challenges posed by ballistic missiles and weapons of mass destruction, the Department of Defense (DOD) has refocused priorities guiding the ballistic missile defense program. The highest priority is assigned to the development and deployment of TMD systems to meet the present and growing threat from ballistic missiles to U.S. forward-deployed forces, allies and friends. In developing its missile defense program, the U.S. will be looking to cooperate in the development and deployment ot theater defenses with many of its allies and friends who share the problem arising from the proliferation of ballistic missiles.

7.2 Allied Consultations and Participation in Ballistic Missile Defense Programs

The Department of Defense (DoD) approach to allied participation in the research, development, and acquisition of ballistic missile defense (BMD) systems has evolved from the concerted activities beginning in 1985 to consult with friends and allies as part of the former Strategic Defense Initiative (SDI) and to have them participate directly in the Program's technology developments consistent with U.S. laws, regulations, polices and international obligations. This process to involve allies and friends in U.S. ballistic missile defense programs gained increased impetus when then Secretary of Defense Aspin restructured and renamed the program, giving priority to Theater Missile Defense (TMD). Further, the Ballistic Missile Defense Organization (BMDO) has been given specific direction from the Secretary of Defense to acquire and field TMD systems before the turn of the century to protect U.S. deployed forces, friends and allies.

NATO has agreed that missile defenses are a part of the solution to the risks posed by ballistic missile proliferation. Recognizing the budget reductions ahead and that there is a commonality of interest among allies and friends regarding the need for missile defenses, the Administration has given high priority to armaments cooperation in this area. At minimum, a strong need is recognized for interoperability of missile defenses among allies and friends, and more importantly, there are opportunities for research and development (R&D) on BMD systems and technology.

The Congress has also recognized the importance of involving allies and friends in BMD programs, specifically, in TMD. In the FY 1994 National Defense Authorization Act, allied nations are encouraged to participate, or increase participation in cooperative U.S. TMD programs, particularly those nations that would benefit the most from deployment of such systems. The Congress has directed that the DoD should develop a plan to coordinate development and implementation of U.S. TMD programs with allies to avoid duplication, increase interoperability, and reduce cost. Further, the Congress directed that a report of the plan be submitted to Congress that will set forth the status of discussions and contributions to TMD cooperation by friends and allies. The report of the plan will be submitted separately from this report. Another report pertaining specifically to the Israeli Arrow system is also being submitted separately.

The current Administration has given high priority to a renewal of the spirit of armaments cooperation. A strong need is also recognized within the Department of Defense for interoperability of missile defenses among allies and friends, and for cooperative R&D on BMD systems and technology. Regarding NATO, the Secretary of Defense has stated that the U.S. support for TMD is in line with the Alliance strategic concept which recognizes missile defenses are a part of the solution to the risks posed by ballistic missile proliferation. He indicated that the U.S. believes it is time to begin discussions with NATO allies collectively on the potential for cooperation in TMD.

Recognizing the need for TMD cooperation in NATO, the Conference of National Armaments Directors (CNAD) at their meeting in October 1993, agreed to establish an Extended Air Defense/ Theater Missile Defense Ad Hoc Working Group (EAD/TMD AHWG). The AHWG, chaired by the U.S., is comprised of delegates from the United Kingdom, Germany, Italy, Canada, The Netherlands, and France. The Group's objective is to define future opportunities and methods of collaboration in the area of TMD. The AHWG agreed to capitalize on the considerable work in the area of TMD already performed by NATO nations. Specific TMD areas being considered for collaboration are early warning, BM/C^3, and weapon systems.

The U.S. and Japan have initiated a TMD working group to discuss possible future Japanese involvement in the program. Japan has produced the PATRIOT PAC-1 missile system since 1985, and will field PATRIOT PAC-2 beginning in 1995. The first of Japan's four planned AEGIS-Class destroyers is operational. The Secretary of Defense has offered Japan the opportunity to cooperate in TMD via codevelopment, coproduction, or licensed production; alternatively, Japan may later purchase new systems off the shelf.

7.3 Major Allied Activities Past and Present

A summary of major contracts, subcontracts and programs covered by international agreements with firms and government research establishments between October 1985 to the present which contribute to missile defense research and development are as follows:

- France: Sensors, Theater Defense Architectures, Free Electron Lasers, Klystrons, Rocket Propulsion Components And Casings, Extended Air Defense Simulations;

- Germany: Pointing/Tracking, Optics, Lethality and Target Hardening, Electron Lasers, Theater Defense Architectures, Infrared Phenomenology, Discussions on Extended Air Defense Test Bed;

- Israel: Electrochemical Propulsion, Magnetohydrodynamics, Shortwave Chemical Lasers, ATBM Interceptors (ARROW), Test Bed, Theater Defense Architectures, ARROW Continuation Experiments (ACES), Test Bed Experiments;

- Japan: Superconducting Magnetic Energy Storage, Josephson Junction Microprocessor, Diamond Optics, Electric Propulsion, Western Pacific Architecture Study;

- Netherlands: Theater Defense Architecture, Electromagnetic Launchers;

- UK: Optical/Electron Computing, Thyratrons, Ion Source And Power Conditioning, Electromagnetic Launchers, Optical Logic Arrays, Countermeasures And Penetration Aids, UK Test Bed, Theater Defense Architecture Analysis, Advanced Lethality Technology, Flight Trials;

- Belgium: Theater Defense Architecture, Laser Algorithms, Mosaic Array Data Compression and Processing Module;

- Canada: Power System Material, Particle Accelerators, Theater Defense Architecture, Sounding Rockets;

- Denmark: Magnetic Optics For Free Electron Laser Beam Steering;

- Italy: Cryogenic Induction, Superconducting Magnetic Energy Storage, Millimeter-wave Radar Seeker, Theater Defense Architecture, Smart Electro-optical Sensor;

- Russia: Electric Thrusters, TOPAZ Thermionic Nuclear Reactor, Tacitrons, Basic Research.

7.4 Summary

Other nation's scientific and technical excellence continue to contribute to the BMD program through allied contractual participation and cooperative research projects. Our friends and allies have made significant technical contributions to both strategic and theater ballistic missile defense efforts. Currently, trends in allied involvement in the redefined BMD program are TMD related and include test beds and technology experiments, technology demonstrations, and other cooperative activities of mutual interest. Continued allied participation and cooperation in the BMD program will provide the framework for developing and deploying effective and interoperable TMD systems.

Chapter 8

BMD Countermeasures And Survivability

- A Test and Evaluation program, wherein proposed systems, subsystems, and components are subjected to simulated threat environments in test simulators, and space flight tests.

Secondly, the formal DoD acquisition process demands that survivability requirements be developed and validated for each military system, and that adequate operational testing be conducted to ensure that systems satisfy those requirements before they are fielded. For BMDO, survivability requirements are developed for both the individual defensive elements and for the overall defensive system. Operational testing or appropriate simulation is likewise required and will be conducted at both levels.

Chapter 8 Ballistic Missile Defense Countermeasures And Survivability

8.1 Introduction

Early in the SDI program, when the focus was on developing defenses against Soviet attack, concerns regarding system survivability, potential Soviet countermeasures, and system Cost Effectiveness At The Margin (CEATM) were critical considerations in formulating ballistic missile defense strategy. Public Law 99-145, Section 222 (dated November 8, 1985) specifically states "A strategic defense system development, test, and evaluation conducted on the Strategic Defense Initiative program may not be deployed in whole or in part unless - (1) the President determines and certifies to Congress in writing that - (A) the system is survivable (that is, the system is able to maintain a sufficient degree of effectiveness to fulfill its mission, even in the face of determined attacks against it)" and "(B) the system is cost effective at the margin to the extent that the system is able to maintain its effectiveness against the offense at less cost than it would take to develop offensive countermeasures and proliferate ballistic missiles necessary to overcome it; ...". To address these concerns, the SDI program aggressively analyzed potential system countermeasures and pursued vigorous development of both passive and active survivability technologies, methods and tactics.

With the current program focused on developing and fielding TMD systems and developing NMD technologies, BMDO efforts in countermeasures and survivability continue but with a different emphasis.

8.2 Countermeasures

8.2.1 Theater Missile Defense

Since 1991 the priority for countermeasures analyses in BMDO has been to further understand the range of potential countermeasures available to the Third World and the effect of Third World technologically feasible countermeasures on Theater Missile Defense systems. BMDO conducted three rigorous Red-Blue Exchanges of TMD systems. These Red-Blue Exchanges investigated possible susceptibilities in the TMD systems and identified and analyzed potential countermeasures. The impact of countermeasures on the effectiveness of THAAD, GBR, PATRIOT, ERINT, Corps SAM, AEGIS SM-2 Block IVA, and Arrow systems was analyzed in these Red-Blue Team interactions. These analyses have resulted in a wide variety of potential technical and operational techniques which could be used by the TMD system designers to mitigate the effects of countermeasures.

In addition to the Red-Blue Exchanges, BMDO completed detailed threat designs of potential TMD countermeasures to ascertain the technical credibility of the countermeasure and to characterize the performance of the countermeasure in support of developing mitigating responses. In addition, BMDO has begun a series of high fidelity experiments of countermeasures and possible counter-countermeasure responses to the designs of TMD systems using Government test beds and simulation facilities, specifically, the National Test Facility and Surveillance Test Bed. Also, BMDO has developed techniques for determining the level of difficulty for Third World countermeasures using a hardware oriented approach whereby a select team of engineers design, fabricate, assemble, and test specific countermeasures to TMD systems. Quantifying the difficulty and the effectiveness of TMD countermeasures provides threat information necessary for deciding on appropriate courses of action for dealing with them in the TMD acquisition programs. Finally, BMDO will begin in 1994 to conduct a series of parametric studies to bound the range of technical feasibility for the most significant classes of countermeasures and, consequently, determine the corresponding impacts on TMD system design.

In summary, BMDO has diligently investigated the technical feasibility of Third World countermeasures and their effect on TMD system performance. This threat development work is a prelude to performing system trade studies and developing detailed design alternatives to provide counter-countermeasures for TMD systems. BMDO will continue these studies to ensure that deployed TMD systems will be able to achieve their operational requirements on a battlefield which includes adversary countermeasures.

8.2.2 *National Missile Defense*

The BMDO Red Team and the NMD Blue Team completed an intensive Red-Blue Exchange on the NMD First Site System. An independent susceptibility analysis was completed by the Red Team, and technologically feasible countermeasures from potential adversaries were devised. The Blue Team developed innovative technical and operational counter-countermeasures to restore any performance degradation from the countermeasures during this study. The information resulting from this NMD Red-Blue Exchange will be used to support the NMD Technology Readiness projects.

8.3 Survivability

The survivability of potential ballistic missile defense systems is ensured through a two-fold approach. First, broad based survivability programs are maintained to support the development of all potential BMD systems. These efforts include:

- A Balanced Hardening Program, which develops survivability technologies such as: electronics that operate in hostile environments; hardened communications systems; and laser/radio frequency jamming mitigation tactics. Once validated, these technologies are available for system developers to tailor them to satisfying system-unique requirements.

- An Environment/Analysis and Simulation program, wherein computer environment models are developed and made available to system developers. Operability demonstrations are conducted, and cost-effectiveness and functional assessments are performed.

- A special Theater Missile Defense survivability program which investigates theater specific issues such as radar cross section reduction techniques and protection from chemical/biological threats.

PROJECT NUMBER: 1101
PROJECT TITLE: Passive Sensors
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	9,822	24,500	26,600

PROJECT DESCRIPTION:
This program performs research and development in: visible through infrared focal plane arrays, cryogenic cooling, optics hardware and cryogenic based signal processing technologies. Specific technology areas include: infrared focal plane arrays using silicon and mercury cadmium telluride materials, focal plane readouts using state-of-the-art electronic components, mirror hardware using silicon carbide or beryllium, innovative cryogenic signal processing techniques; maintenance of optical and electro-optical test facilities to verify component performance, cryogenic cooler development to cool focal plane arrays and associated optical hardware, sensor performance models and optical signature software codes which allow modeling of optical systems.

PROJECT NUMBER: 1102
PROJECT TITLE: Radar
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	1,631	10,000	9,000

PROJECT DESCRIPTION:
This project addresses advanced radar system designs and critical component technologies needed to build long-range radar systems with search, detection, tracking, discrimination and kill assessment functions for multiple targets. Targets are threat ballistic missile reentry vehicles and associated objects at both endo- and exoatmospheric ranges. This project provides the critical technologies for current as well as future radar systems that support BMDO architectures.

The Large Radar Technology program develops an advanced radar technology base necessary to meet the functional performance requirements of large aperture, phased array radars to support ballistic missile defense during all phases of threat flight. Emphasis is placed upon endo- and exoatmospheric tracking, fire control, and engagement functions with focus on developing solid-state RF components, fiber optic interconnects and waveform generating and processing components.

The Innovative Radar Technology program develops radar technologies which have direct benefit for national and theater radars operating in electronic countermeasure and nuclear environments. Projects planned include techniques to coherently combine signals radiated from multiple radars, resonant target identification phenomenology, synthetic aperture radar hardware and demonstrations, and track error compensation technologies.

PROJECT NUMBER: **1104**
PROJECT TITLE: **Signal Processing**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	6,914	7,100	12,000

PROJECT DESCRIPTION:
This project develops and demonstrates the technology, techniques and components to meet with stringent signal and data processing requirements in support of theater and national ballistic missile defense needs. It accomplishes this task by advancing the radiation hardened, high-speed microelectronic, microprocessor, and analog circuit technology base. To meet ballistic missile mission objectives, on board processors must perform large numbers of computations to perform surveillance, acquisition, tracking, intercept, and kill assessment of missiles and reentry vehicles. These elements must survive and continue to perform in potential high levels of natural and man made nuclear radiation. Selected elements must continue to operate through very high flash levels of nuclear burst. High-speed and low power Very Large Scale Integrated (VLSI) electronic circuits and memories with performance comparable to DoD Very High-speed Integrated Circuit (VHSIC) technology must be developed to achieve very high levels of performance and radiation hardening. Space borne electronics must use advanced packaging techniques to reduce satellite size, weight, power, and total system costs. Further development of these technologies are absolutely critical to lowering the risk and system costs involved with a deployment/full scale development decision. This project will produce two radiation hardened state-of-the-art 32 bit Reduced Instruction Set Computers (RISC) for space applications. The level of testability, fault tolerance and radiation immunity built into these processors distinguish the RH32 processors from others available or planned. and enable the RH32 to operate through the harsh space radiation environment. A companion effort, the RISC Ada Environment (RISCAE), will develop the software environment for both processor designs. Other programs include a Wafer Scale Vector Processor for very high-speed signal processing, and advanced packaging to reduce size, weight and power of system microelectronics.

PROJECT NUMBER: **1105**
PROJECT TITLE: **Discrimination**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	4,000	58,119	52,014
0603217C RDT&E	54,404	29,382	14,986

PROJECT DESCRIPTION:
This task area is responsible for characterizing the optical and radar signatures of the threat objects (e.g. penaids and RVs) and backgrounds for development of effective target acquisition and discrimination techniques for ballistic missile defense. Collection and analysis is done on celestial and atmospheric backgrounds, development of phenomenology models, discrimination algorithms (Lexington Discrimination System (LDS)), and integrated tools for a realistic assessment of surveillance, acquisition, tracking, and discrimination techniques.

Appendix

Current Program, Projects, And Activities - Narrative Description And Status

PROJECT NUMBER: 1106
PROJECT TITLE: Sensor Studies and Experiments
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	30,066	28,500	35,000
0603217C RDT&E	86,311	48,600	40,800

PROJECT DESCRIPTION:
This project conducts "tech-demo" experiments to integrate and assess newly developed sensor technologies in as realistic an operational environment as possible before they are transferred to missile defense systems elements.

The Theater Missile Defense (TMD) specific effort in this project comprises tactical cueing and netting demonstrations, including TMD weapons systems (i.e., PATRIOT, THAAD, etc.) cued by tactical sensors (Joint Tactical Ground Station (JTAGS), SPY-1, TPS-59, etc.). Additional sensor development includes tactical processing and application of space sensor data in the TALON SHIELD project and airborne sensor technology development and contingency demonstration. Trial results of the United Kingdom's Multifunction Electronically Scanned Adaptive Radar (MESAR) will continue to be monitored. Data collected within this project are critical to the design of all TMD surveillance and weapon sensors and sensor processing algorithms. This project includes TMD sensor upgrades and technologies with application to theater missile defense. These improvements provide sensor alternatives that address critical TMD sensor needs which includes netted sensor data processing improvements at key TMD nodes. These improvements are accomplished through modifications of existing sensor systems and/or the introduction of new technologies.

The Midcourse Space Experiment (MSX) will provide the system functional demonstrations, target characterization data, statistically significant background data, and the technology demonstrations necessary for the midcourse sensor platforms to meet Milestone II. MSX will launch in 1994, and will perform a variety of experiments during its five year life span. The principal sensor is a cryogenic MWIR/LWIR/VLWIR radiometer and spectrometer system with high off-axis rejection optics, which will operate for 18 to 20 months. MSX will provide data on real midcourse targets against real backgrounds at realistic system ranges for use in system ground demonstrations; provide high quality target and background phenomenology data for further development of robust models of representative scenes; demonstrate key functions such as acquisition, tracking, hand off and bulk filtering; provide multiwavelength target phenomenology data for assessing optical discrimination algorithms; and demonstrate the capability to integrate key technologies into a working platform similar to proposed operational midcourse sensor designs.

The Red Tigress program consists of a series of joint U.S./U.K. sounding rocket launches to measure the signatures of advanced penetration aids. Data collected during these launches will be used to validate discrimination algorithms for TMD sensor and interceptor system elements. This program was unfunded in FY 1994.

PROJECT NUMBER: 1110
PROJECT TITLE: Sensor Integration
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	25,306	0	0

PROJECT DESCRIPTION:
This program develops advanced miniature components for surveillance, acquisition, tracking, navigation, and image processing for space systems; integrates the lightweight components in a spacecraft payload, and includes the launching, mission operations, and data processing required to understand the performance of these assemblies in a long life space environmental mission.

This project is designed to integrate and perform flight qualification of some of the most advanced BMDO lightweight technologies being developed. Lightweight spacecraft are being designed, built, and launched in the sensor integration program, usually referred to as the Clementine spacecraft. These spacecraft will be flown to fully characterize the effects of a radiation stressed environment on the lightweight technologies. The Clementine spacecraft has a lightweight suite of sensors (Ultraviolet/Visible, Near Infrared, Long Wave Infrared, Light Detection And Ranging (LIDAR), and Star Trackers), lightweight attitude control systems (Inertial Measurement Units and Reaction Wheels), a 32-bit parallel computer processor architecture, high energy storage batteries, and high-power density solar cells. This spacecraft will be flown in January 1994 using the Moon and a near-earth-asteroid as natural targets to measure the sensor performance. These spacecraft are being developed under a cooperative agreement with NASA to transfer DoD developed technologies to the civilian scientific sector. The Clementine program is to be transferred from BMDO to the Navy in FY 1994.

PROJECT NUMBER: 1111
PROJECT TITLE: Advanced Sensor Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	36,527	48,000	48,000

PROJECT DESCRIPTION:
This program provides for the development, independent government testing, and integration of state-of-art advanced technology sensor systems including the demonstration of them in realistic scenarios. Specifically, it develops follow-on sensor components, and subsystems, integrates developmental systems, and conducts functional demonstrations to support applications. The focus of follow-on sensor technologies, while exploring increased capabilities in the infrared, will include other small, lightweight, low power sensor concepts such as synthetic aperture radars, LIDAR, hyper spectral UV-to IR, on-FPA processing, multicolor FPA's, higher efficiency/long life cryocoolers, etc.

This project also provides funding for the Miniature Sensor Technology Integration (MSTI) program. The MSTI program will test and verify on-orbit advanced miniaturized sensor technologies for space based surveillance and ballistic missile track capability as well as environmental/ecological dual use applications. Using off-the-shelf hardware to the maximum extent possible, MSTI satellites are manufactured and launched rapidly, enabling MSTI technology achievements to aid the development efforts of space based surveillance systems and demonstration of system operational concepts in realistic scenarios. MSTI will demonstrate monocular tracking capability in several IR wavebands, and will serve as a test bed for hand over solutions to an interceptor with sufficient accuracy to enable a missile intercept. The MSTI program is to be transferred to the Air Force in FY 1994.

PROJECT NUMBER: 1201
PROJECT TITLE: Interceptor Component Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	8,000	5,000	5,000
0603217C RDT&E	11,726	22,500	28,500

PROJECT DESCRIPTION:
This project is developing advanced components for lightweight, low cost interceptors for national and theater missile defense. Technology development efforts focus on addressing the more stringent requirements, such as on board discrimination, greater kinematic capability, reduced mass and low cost.

The Pilotline Experiment Technology (PET) is developing producibility and automated testing techniques for hardened LWIR HgCdTe focal plane arrays. The LWIR Advanced Technology Seeker (LATS) program is developing seeker components for long-range acquisition, such as microlenses, cooled optics, micro scanning and gamma circumvention circuitry. These technologies will be integrated and demonstrated in a Technology Seeker Evaluation Unit (TSEU). This project is also developing a gelled propellant Divert And Attitude Control System (DACS) for THAAD.

PROJECT NUMBER: 1204
PROJECT TITLE: Interceptor Studies and Analysis
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	6,115	0	0

PROJECT DESCRIPTION:
This project funds technical and engineering resources required by Government Program Managers to plan and conduct technology investigation programs within the Interceptor Technology

Directorate. Resources are used to perform analyses, develop innovative concepts in the particular technologies, plan and implement major experiments, perform data reductions and analysis of experiment results, and perform system engineering studies on interceptor technology concepts. Technical and engineering support is provided to all phases of interceptor technology program design, development, and test, including systems requirements/concepts definition, systems engineering and design, flight test planning and conduct, and range and on-orbit operations.

PROJECT NUMBER: **1209**
PROJECT TITLE: **Endoatmospheric Interceptor Technologies**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	2,500	0	0

PROJECT DESCRIPTION:
The Endoatmospheric Interceptor Technologies Program is a comprehensive approach to coordinate the development and demonstration of advanced components critical for small, lightweight (<20 kg) high velocity (4 km/s) interceptors. The aero-thermal and aero-optical issues associated with hyper velocity flight in the atmosphere are being resolved. Advanced window materials and cooling techniques are being developed and tested. This enables interceptor velocity, lethality and overall performances to exceed the current low velocity interceptor flight capability. This project is to be discontinued after FY 1994.

PROJECT NUMBER: **1212**
PROJECT TITLE: **D-2 Program**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	4,600	0	0

PROJECT DESCRIPTION:
This project will demonstrate the launch of a guided interceptor (D-2) from a Hypervelocity Launcher (HVL) with associated fire control to demonstrate the potential of a HVL system as a candidate weapon system for Theater Missile Defense (TMD) in the near term and other longer range applications in the far term. This involves the development of the Gee-hardened D-2 projectile which is a command guided to terminal homing interceptor. This project will be discontinued after FY 1994.

PROJECT NUMBER: **1214**
PROJECT TITLE: **Advanced Interceptor Technology (AIT) Program**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	15,000	0	0

PROJECT DESCRIPTION:
This effort encompassed demonstrating key space interceptor and satellite technologies, based on system requirements and designs, and performing risk reduction. The Brilliant Pebbles (BP) program developed the primary technology in the AIT program. This project is to be discontinued after FY 1994.

PROJECT NUMBER: **1215**
PROJECT TITLE: **Boost Phase Intercept/ Exoatmospheric**
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	15,000	0	0
0603217C RDT&E	16,489	61,100	65,300

PROJECT DESCRIPTION:
The purpose of this project is to demonstrate via test follow-on technology developments as they apply to Boost Phase Intercept (BPI) as they apply to Theater Missile Defense (TMD). The TMD threat cannot yet be countered by any single solution; it will require a balance of integrated attack operations, comprehensive active defense against enemy missiles in boost and ballistic phases, a robust C^3I and a surveillance capability responsive to unique theater missile characteristics. Present BMDO/TMD architectures focus on midcourse and terminal defenses which allow fragments of the missile body and/or warheads to inflict damage on friendly areas. By adding BPI defensive layers, tremendous leverage can be brought to bear on the enemy to significantly reduce the utility of his Theater Ballistic Missiles (TBMs). During a TBM's boost phase, the missile is readily visible, slow moving and extremely vulnerable. BPI of TBMs can cause missile debris to fall on enemy territory or fall far short of the intended target and thus thin out the number of TBMs exposed to subsequent defensive layers. BPI will reduce the burden on terminal defenses. Thus the goal is for a well paced BPI program. The demonstration will provide the foundation for later intercept options this decade.

The BPI Program is currently in the early phase of a demonstration program to develop and demonstrate the capability of a fighter launched kinetic energy weapon. The program will maximize the use of existing assets and infrastructure by using an off board sensor platform for cueing and tracking of TBMs and for providing updated target positions to the interceptor missile until the interceptor is in the acquisition range of the TBM. This program will be jointly funded by the Air Force and BMDO with Navy and Army participation.

PROJECT NUMBER: 1216
PROJECT TITLE: Sea Based Theater Wide Defense
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	80,000	17,725	30,590

PROJECT DESCRIPTION:
The Bottom-Up Review (BUR) of FY 1994 identified Sea Based Theater Wide Defense as a high payoff advanced concept that builds on the core major acquisition program Sea Based Area TBMD (AEGIS/SM-2 Block IVA) (Project 2213) and the existing infrastructure of AEGIS ships. This program establishes sea based theater capability using an upper tier interceptor and AEGIS weapons system program, under Theater Missile Defense in FY 1994. The Lightweight Exoatmospheric Projectile (LEAP) technology demonstration program originated under Project 1202. These efforts provided the critical technology integration and testing needed to support the first phase of this TMD demonstration program. The entire LEAP technology demonstration program consolidated under Project 1210 in FY 1994.

Funding in Project 1216 in FY 1994 includes the baseline funds for the sea based theater program including those activities necessary to proceed through a Milestone 0 to a Milestone I. Such activities include support of an independent Cost and Operational Effectiveness Analysis (COEA), THAAD/AEGIS compatibility studies, operational mode studies, and interceptor safety/system engineering efforts. This program will build on the TERRIER/LEAP technology demonstration efforts to date and will provide for the final fully integrated intercept at sea. In order to minimize cost, reduce risk, and enable early demonstration, maximum use will be made of existing hardware, test facilities, test infrastructures, and procedures. Early tests performed using deployed extended range missile systems (TERRIER) will transition to STANDARD missile (SM-2 Blk IV) with the AEGIS weapons system.

Funding under Project 1210 in FY 1994 provides for the development, independent government testing, and experimental integration of state-of-the-art component technology to provide risk reduction for systems that could be deployed prior to the beginning of the twenty-first century. The project includes further development of Lightweight Exoatmospheric Projectiles (LEAP) and their technologies, and planning for transition of the LEAP technologies into the Theater Missile Defense Program. Funding under this program provides for continued LEAP flight testing at Wallops Flight Facility and the Naval Air Warfare Center (NAWC/WPNS) at Point Mugu, CA. Funding under this program also provides for development of advanced LEAP integrated technologies, and advanced LEAP test planning for potential weapon system applications, including SRAM/LEAP technology demonstrations and PATRIOT/LEAP compatibility testing.

Funding under Project 1210 further provides for the planning and testing which could provide a low cost, low risk, demonstrated technology insertion option, based on LEAP interceptor technologies, using existing STANDARD missile systems. This will provide a comprehensive demonstration of technology in support of developing an effective, near term exoatmospheric sea based theater missile defense capability. The program will perform a series of suborbital flight tests of Navy STANDARD missiles with increasingly challenging mission scenarios which will validate the capability of LEAP technologies to perform exoatmospheric intercepts of theater missile type targets. A step-by-step approach will be used to demonstrate all the necessary elements of a sea-based TMD system: exoatmospheric interceptors, boosters, sustainers, kick stages, shipboard launch systems, fire control systems, and satellite cueing capability. The program will culminate in a series of realistic, fully integrated intercepts at sea.

PROJECT NUMBER: 1217
PROJECT TITLE: EKV Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	57,200	120,000	113,000

PROJECT DESCRIPTION:
The objective of the Exoatmospheric Kill Vehicle (EKV) Technology effort is to design, fabricate, ground test, and flight test state-of-the-art EKV technology which can accomplish hit-to-kill (non-nuclear) intercepts of Intercontinental Ballistic Missile (ICBM) and Submarine Launched Ballistic Missile (SLBM) Reentry Vehicles (RVs) in the midcourse of their trajectories. Midcourse sensors will acquire, track, and pass threat cluster information to the Command and Control Element, which will cue the interceptors and provide updates if they are available. Using on board sensors, the interceptors will acquire the threat cluster and select the RV, and kinetically destroy it.

The EKV program is structured over at least three periods into the next decade and achieves successively increasing deployment capability should a contingency deployment requirement arise. The competitively awarded GBI-X contracts, in place since October 1990 to address EKV technologies, are the focus of meeting early NMD technology readiness requirements.

PROJECT NUMBER: 1302
PROJECT TITLE: Chemical Laser Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	54,269	77,500	77,500

PROJECT DESCRIPTION:
The Chemical Laser (CL) program is developing high leverage High Energy Laser (HEL) technologies for future ballistic missile defense against an evolving, proliferating threat. The program is composed of a ground integration/demonstration of HEL components developed by BMDO over the past decade as well as the development of advanced HEL technologies.

Critical technical issues for the SBL element can be grouped into five areas: the laser device; beam control; optics; Acquisition, Tracking, Pointing and Fire Control (ATP/FC); and high-power integration. The laser or beam generating device is a hydrogen fluoride (HF) chemical laser which produces the high-power laser beam by photon extraction from excited HF molecules, generated by the energetic reaction of hydrogen and fluorine. In multiple tests from 1990 through 1993, the Alpha HF laser demonstrated near-weapon-level continuous wave operation. The Alpha design is space compatible and directly scalable to weapon-level power requirements. Required beam control technology was demonstrated by the Laser Optics Demonstration Experiment (LODE) program in 1987. Required optical technology can be subdivided into two classes: small high-incident-intensity optics for handling the high-power beam within the SBL and large moderate-incident-intensity optics for directing the expanded high-power beam toward the target. Required small high-incident-intensity optics have been demonstrated in a number of SBL programs, including Alpha. The Large Advanced Mirror Program (LAMP) completed in 1989, demonstrated a 4-meter diameter beam director primary mirror whose design is space compatible and directly scalable to weapon size. ATP/FC technology is being developed in Project 1305 and has made excellent progress toward developing the technology to meet SBL ATP/FC requirements. High-power integration is being demonstrated in the Alpha And LAMP Integration (ALI) program. In ALI, the Alpha, LODE, and LAMP hardware and technologies are being integrated for ground demonstration of an SBL high-power beam train in FY 1996. In parallel, a number of efforts are developing additional promising technologies with the potential for significant cost, weight, and/or brightness improvement. These efforts include continued development of very-low-absorbance optical coatings and mirror substrates which allow high-power optics to be uncooled (ultralightweight), shorter wavelength lasers that may achieve equivalent range performance with a smaller diameter beam director mirror (HF overtone), molecular (rather than mechanical) methods for compensation of beam aberrations to produce the required beam quality (Stimulated Brillouin Scattering (SBS) phase conjugation), and manufacturing techniques for improving the producibility and decreasing the cost of large optics (Large Optical Segment (LOS) Program).

After the completion of ALI, the ALI hardware and designs will be repackaged into an operational configuration. A conceptual design and program plan for this demonstration, named Star LITE, has already been developed. In Star LITE, ALI hardware and designs are repackaged, mated with an ATP suite, and ground tested. Upon completion, an option can be executed to mate Star LITE with a launch vehicle for a space demonstration of the weapon scalable Star LITE SBL against simulated ballistic missiles targets. Completion of the Star LITE experiment will demonstrate the readiness of the SBL for a decision on the development of a full scale prototype.

PROJECT NUMBER: 1303
PROJECT TITLE: Neutral Particle Beam Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	7,392	0	0

PROJECT DESCRIPTION:
The Neutral Particle Beam (NPB) project exploits the capability of a stream of atomic particles to penetrate into a target (1) to provide lethal energies and/or (2) to induce signatures that permit discrimination. Such a beam is capable of effecting kill of ballistic missiles in the boost, post boost, and midcourse phases. This project is to be discontinued after FY 1994.

PROJECT NUMBER: 1305
PROJECT TITLE: Acquisition, Tracking, Pointing, and Fire Control Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	6,492	12,500	12,500

PROJECT DESCRIPTION:
Acquisition, Tracking, Pointing and Fire Control (ATP/FC) efforts will advance the technologies required to perform critical functions for candidate Directed Energy Weapons (DEW) concepts to be deployed after the initial deployment of TMD and NMD architectures. These functions include acquiring, identifying, and prioritizing the targets to be engaged, precision tracking of each target, selecting and establishing the line-of-sight to the target aim point, holding the beam on the aim point, assessing the results, and reinitiating the sequence to engage a new target.

Efforts within the ATP/FC technology base address major tracking/pointing component performance issues, and development of technologies for advanced ATP/FC integrated experiments. Among these are the Advanced DEW Active Precision Tracker (ADAPT) program to design an advanced ATP system for a comprehensive space demonstration. A series of field experiments with payloads on high altitude balloon experiment (HABE) platforms will obtain critically needed phenomenology data and build upon technology base products to demonstrate all the tracking and functional integration needed to control single target engagements. ATP/FC simulation tools and algorithms are being developed for directed energy weapons, with current emphasis to support HABE testing. In addition, the Space Integrated Controls Experiment (SPICE) assesses the ability and means of incorporating passive and active vibration damping systems in the design of structures requiring high precision pointing accuracy.

PROJECT NUMBER: 1307
PROJECT TITLE: Directed Energy (DE) Demonstrations
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	1,991	0	0

PROJECT DESCRIPTION:
This project includes three efforts. The first is the Aircraft Based Laser (ABL) which is a Directed Energy Weapon (DEW) concept for theater missile defense. Experiments and analysis leading to an understanding of the operational effectiveness of this concept are performed.

A second effort within this program is studying the feasibility of scaling the Diode-Pumped Solid-state Laser (DPSSL) to levels adequate for airborne weapon applications. Russian technology is being evaluated to assess the possibility of a joint program to exploit their past investments in directed energy weaponry.

A third effort is a series of radially inbound missile defense tests using the Mid Infrared Advance Chemical Laser (MIRACL) and Sea Lite Beam Director (SLBD) at the White Sands Missile Range (WSMR), White Sands, NM. This is a jointly funded BMDO/U.S. Navy/United Kingdom Royal Navy effort.

PROJECT NUMBER: 1403
PROJECT TITLE: Computer Engineering Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	0	2,500	0

PROJECT DESCRIPTION:
This effort provides support and technologies required for advanced Command, Control and Communication (C^3) concepts through short-term demonstrations and integration with other sensor and interceptor technology programs. There are several projects supported by this PMA. The first supports the development of missile tracking software for PAVE PAWS and BMEWS early warning radars. Radar track correlation and cueing techniques will be matured. Other sensors, such as the Miniature Sensor Technology Integration (MSTI) satellite, or prototype command nodes may be included with operational sensors. Satellite based inflight target updates will be investigated and demonstrated with experimental interceptor test beds. This may allow very large areas to be defended by theater weapons.

PROJECT NUMBER: 1405
PROJECT TITLE: Communications Engineering Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	1,932	500	0

PROJECT DESCRIPTION:
Develop communications technology to support operational requirements for defensive systems. Develop communications components, both Radio Frequency (RF) and laser communications, for space-to-space, space-to-ground, and ground-to-space links. Efforts to define requirements for space qualification and radiation hardness of Extremely High Frequency (EHF) components needed for robust communications are included.

PROJECT NUMBER: 1501
PROJECT TITLE: Survivability
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	3,024	4,900	3,800
0603217C RDT&E	3,321	3,000	3,000

PROJECT DESCRIPTION:
Develops and demonstrates survivability technologies to ensure that Ballistic Missile Defense (BMD) elements can perform their mission in all expected environments and the face of all expected hostile threats. Approaches include: studies/analyses; defense suppression threat mitigation technologies development; Survivability Enhancement Option (SEO) development; Electronic Data/Guidelines for Element Survivability (EDGES) development, Electromagnetic Environmental Effects (E^3) engineering support, survivability/operability demonstrations, development of issue resolution approaches, development of Anti-Radiation Missile (ARM) Countermeasure Evaluator (ACE), and hardened technology integration. Technologies will be available for incorporation into BMD elements at Engineering and Manufacturing Development (EMD) and will also provide near term improvements to existing systems. Demonstrations will provide necessary risk reduction evidence to support milestone decisions.

PROJECT NUMBER: 1502
PROJECT TITLE: Lethality and Target Hardening
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	29,064	32,800	29,400
0603217C RDT&E	1,358	0	0

PROJECT DESCRIPTION:
The Lethality of BMD weapons is a measure of BMD systems effectiveness in fulfilling defense mission requirements. The Lethality and Target Hardening program is developing a necessary and sufficient understanding of physical principles involved in defensive weapon/target interaction, target response and kill modes, and impact signatures for discrimination and damage assessment.

This task provides supporting lethality technology for developmental ballistic missile defense ground based kinetic energy weapons. This supporting lethality technology includes lethality phenomenology analyses and tests to evaluate kinetic energy warheads hit-to-kill interceptors against simulated threats. Theater missile threats include conventional, chemical, biological, and nuclear warheads. Common validated lethality criteria for a high confidence kill against any/all threat warheads is required. These lethality criteria are developed in coordination with TMD interceptor development. Lethality of the interceptors will be validated in cooperation with interceptor demonstration/validation flight test and evaluations.

PROJECT NUMBER: 1503
PROJECT TITLE: Power and Power Conditioning
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	7,060	10,000	10,000

PROJECT DESCRIPTION:
This program focuses on space nuclear power, specifically the TOPAZ International Program (TIP). The TIP consists of three major components: an extensive series of nonnuclear ground tests to understand the capabilities and limitations of the TOPAZ II thermionic system, basic research with an international team of thermionic and materials experts, and critical component design for increased power generation (the 40 kW program) using knowledge gained from the TOPAZ II design.

The remaining BMDO power program focuses on conventional power technologies. The conventional power goals are to develop, flight test, and transition technology to both the military and commercial sectors. These include lightweight, low volume, low cost, and long life components capable of meeting a variety of mission requirements. Technical goals include the achievement of 15 W/kg power systems, procurement costs of less than $5000/W, satellite lives of at least 10 years, and a significant decrease in satellite launch volume.

PROJECT NUMBER: 1504
PROJECT TITLE: Materials and Structures
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 96
0603216C RDT&E	800	0	0
0603217C RDT&E	5,609	7,000	11,000

PROJECT DESCRIPTION:
The Materials and Structures (M&S) Project conducts research, development and flight and ground test demonstrations in lightweight structural materials, adaptive and multifunctional structures technology, propulsion/thermal/ optical materials, tribomaterials, superconductor devices, and space environmental effects.

M&S supports Sensors and Interceptor activities through the application of advanced materials and structures development and manufacturing technologies to element designs. These efforts will provide for exposure of critical material samples to the natural space environment, reduce vibration through the application of improved active and passive damping material, provide lightweight ultra stiff one step producible composite structures and non-contaminating optical baffles.

Follow-on M&S projects focus on providing advance materials and structures technology demonstrations to meet the extreme pointing and tracking, secure communications and enhanced discrimination requirements of near and far term BMDO systems as they mature in development. To gain confidence in the ability of these systems to operate in the natural and threat environments, requires demonstration of advanced composite and adaptive structure technologies. Superconducting devices are also manufactured and demonstrated to provide orders of magnitude increased capabilities in secure communications and target discrimination.

M&S projects focus on providing advisory services and critical data on lightweight advanced composite structures for theater interceptor systems. These efforts provide independent assessments and assist in identifying structural components and subsystems where interceptor system weight can be reduced in a cost effective manner. Candidate items will be fabricated to demonstrate performance and manufacturabilily.

PROJECT NUMBER: 1601
PROJECT TITLE: Innovative Science and Technology (IS&T)
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	**FY 1995**	**FY 1996**
0602217C RDT&E	41,510	60,000	60,000

PROJECT DESCRIPTION:
Explore innovative science and engineering for several technologies of interest to BMDO.

Invest seed money in high risk technologies that could dramatically change how BMD develops. Cause and exploit breakthroughs in science to keep BMD at the foremost edge of what is possible. Conduct proof-of-concept demonstrations that transitions technology to development programs.

PROJECT NUMBER: 1602
PROJECT TITLE: Small Business Innovative Research
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	**FY 1995**	**FY 1996**
0602217C RDT&E	31,543	46,460	46,774

PROJECT DESCRIPTION:
Explore innovative concepts pursuant to PL102-564 which mandates a two-phase competition for small businesses with dual-use innovative technologies.

PROJECT NUMBER: 1700
PROJECT TITLE: Flight Test / Launch Activities
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	42,996	0	0

PROJECT DESCRIPTION:
Define, develop, and conduct fast response, ground based preflight verification and ballistic or space flight testing of unique concepts and high yield approaches for BMD weapons, seekers, and targeting applications that might be deployed beyond the turn of the century in support of Other Follow-on systems. Provide experienced launch and flight test teams including: launch vehicle procurement; launch services; payload processing; payload integration; mission operations/planning; range operations/ integration; mission analysis; and test operations. Four competitive contracts to provide commercial orbital launches exist: two each for 500 lb and 2500 lb payload classes.

This project is a consolidation of projects 1701 and 1702.

PROJECT NUMBER: 2102
PROJECT TITLE: Spaced and Missile Tracking System (SMTS)
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0604217C RDT&E	0	120,000	150,000

PROJECT DESCRIPTION:
The Space and Missile Tracking System (SMTS), formerly Brilliant Eyes (BE), is a satellite sensor system designed to support strategic and theater ballistic missile defense. A constellation of SMTS satellites provides global (below-the-horizon and above-the-horizon) access of ballistic missiles in their boost, post boost, and midcourse phases in response to directed tasking from the Command and Control Element (C^2E). In addition, SMTS peacetime operations include monitoring and collecting data on ballistic missiles worldwide and supporting Air Force space surveillance missions.

SMTS satellites carry a suite of short, medium, and long wavelength infrared and visible sensors. These sensors acquire and track ballistic missiles in the boost phase and continue tracking and discriminating the reentry vehicles from debris and penetration aids throughout the ballistic flight of the missiles. The satellites are in low earth orbits to track above-the-horizon in the midcourse phase of the missile trajectories. The shorter ranges, compared to high altitude (geosynchronous) early warning satellites, and above-the-horizon viewing allow the SMTS sensors to track ballistic missiles after the boosters stop burning and the missile bodies cool to provide highly accurate estimates of the missile trajectories to support ballistic missile defense. SMTS can either be cued by an early warning sensor, such as DSP or its follow-on, or can be actively monitoring small areas of interest in anticipation of missile launches.

SMTS tracking data supports active defense, passive defense, attack operations and command and control. SMTS continually tracks ballistic missiles in flight to support situational awareness, apportionment, and support the optimum allocation of defense assets. SMTS allows the interceptors (Ground Based Interceptors, Theater High Altitude Area Defense and Sea Based Theater Wide Defense) to have the maximum time for fly out, generating the maximum possible defended area from each interceptor site. SMTS cues radars (Ground Based Radars and Ship Based Radars) increasing their detection range by focusing their energy to smaller volumes to acquire targets earlier. The interceptors can be launched and updated based on SMTS track data. SMTS data can be converted into accurate reentry vehicle impact point and time predictions enabling defensive measures to be taken. Precise and timely launch point estimates, in theaters of interest, enable prompt counterstrikes against missile launchers.

During peacetime SMTS monitors ballistic missile tests worldwide collecting threat development, deployment, signature and trajectory data. This allows defenses to maintain and optimize their effectiveness as new threats appear. In addition, SMTS tracks satellites for cataloging and warning to fill voids and greatly improve the Air Force space surveillance network.

The major programmatic and technical objectives addressed by this program include: (1) demonstrate technology maturity, performance at natural space radiation levels, producibility, and lifetimes of focal plane arrays, cryocoolers, communication components and processors; (2) validate sensor and satellite designs and performance with real-time simulations and hardware-in-the-loop brass boards: (3) demonstrate critical system capabilities, functions, and distributed sensor tracking performance with on-orbit satellites; (4) substantiate affordability by validating cost models based on fabrication of critical technology components; (5) demonstrate cost effective supportability by validating maintenance and support concepts that integrate product development practices and procedures; (6) demonstrate that the operational SMTS system design satisfies the following Critical Operational Issues (COIs): operational performance, command, control, and communication, suitability, interoperability and positive control.

PROJECT NUMBER: 2104
PROJECT TITLE: Ground Based Radar
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	24,849	8,000	11,000
0604216C RDT&E	234,000	173,200	157,450
0604225C RDT&E	0	0	9,790

PROJECT DESCRIPTION:
The Theater Missile Defense Ground Based Radar (TMD-GBR) is the theater radar supporting the Theater High Altitude Area Defense (THAAD) system. The TMD-GBR meets an immediate requirement for a more capable, wide area defense radar to provide surveillance and fire control support to the THAAD missile system in the UTTMDS architecture and to provide cueing support to lower tier systems such as PATRIOT. The TMD-GBR utilizes state-of-the-art radar tech-

nology to accomplish its required functions of threat attack early warning, threat type classification, interceptor fire control, external sensor cueing, and launch and impact point estimation. Of particular note will be TMD-GBR's capability to perform threat classification against theater tactical ballistic missiles, and then, kill assessment after intercept. In addition to providing fire control support for THAAD and cueing support to the lower tier, the TMD-GBR will also have residual capability against air breathing threats. Starting in FY 1995, the TMD-GBR Demonstration/Validation (Dem/Val) and User Operational Evaluation System (UOES) radars will be tested at the White Sands Missile Range (WSMR) in New Mexico.

The design and fabrication of the TMD-GBR and the NMD-GBR radars are based upon the modification of the TMD-GBR to meet the needs of the NMD program. The TMD-GBR radar's antenna technology is based upon the use of solid-state transmit and receive modules. The NMD-GBR has been restructured into a radar technology demonstration program. The objective of this restructured effort is to resolve the following critical NMD-GBR technology issues: discrimination, target object map, mechanical or electrical scan, and kill assessment. Using the Defense Planning Guidance, an incremental program will be developed which leverages advances under the TMD-GBR program to resolve these issues which are applicable to NMD. This program structure, by leveraging TMD developments, provides a cost-effective method for resolving the NMD-GBR critical issues and allows the government both flexibility and limited liability as this program evolves.

PROJECT NUMBER: 2207
PROJECT TITLE: PATRIOT
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0208060C PROC	120,719	255,063	435,622
0604216C RDT&E	80,684	69,240	30,960
0604225C RDT&E	42,097	217,200	205,620

PROJECT DESCRIPTION:
PATRIOT is a long-range, mobile, field Army and Corps air defense system, which uses guided missiles to simultaneously engage and destroy multiple targets at varying ranges. Current threat Theater Ballistic Missiles (TBMs) with significantly improved range and accuracy have increased the threat against PATRIOT air defense sites or defended assets. This could result in the destruction of air defense sites and provide the enemy air superiority once an attack is initiated. The current PATRIOT missile requires improved performance and increased accuracy to counter the evolving threat and to increase its contribution to the lower tier of the theater segment of a Theater Missile Defense (TMD) system. The PATRIOT missile program, which entered production in 1979, is a Major Defense Acquisition Program (MDAP). It has successfully evolved through two major improvement programs, PATRIOT Anti-Tactical Missile (ATM) Capability (PAC) 1 and 2. Also, as a result of analysis of PATRIOT operations in Desert Storm, the Quick Response Program (QRP) was initiated to incorporate several near term hardware/software changes to upgrade PATRIOT performance. The PAC-3 Growth Program is the latest evolution of the phased material change improvement program to PATRIOT. The material changes represent capability improvements to address the PAC-3 Operational Requirements Document (ORD) and are planned

over a multiyear period. Fielding will range from the already funded QRP beginning in FY 1993 for near term deployment, to the Configuration 3 of the PAC-3 Program ending in FY 1999 for the far term deployment. The program elements funded by the Ballistic Missile Defense Organization (BMDO) for TMD improvements are: radar enhancements (QRP); Guidance Enhancement Missile (GEM); PAC-3 missile; radar enhancements phase III; remote launch; communications upgrades; and THAAD integration/cueing.

There are two missile candidates for selection as the PAC-3 missile. ERINT, developed by Loral Vought Systems, which exploits hit-to-kill technology and the Multimode Missile, developed by Raytheon, which is a variant of the PATRIOT missile and incorporates an active Ka-band seeker, improved propulsion system and aimable warhead. In February 1994, the Army selected the ERINT missille as the PAC-3 missile. A Defense Acquisition Board review was conducted in May 1994 and approved entry of the ERINT missile into Engineering and Manufacturing Development (EMD). The technology developed in the Multimode Missile program will continue as part of a risk mitigation program.

PROJECT NUMBER: 2208
PROJECT TITLE: ERINT
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0604216C RDT&E	97,000	58,460	19,580

PROJECT DESCRIPTION:
The ERINT missile was considered along with the PATRIOT Multimode Missile for selection as the PAC-3 missile. This project was to demonstrate that ERINT is an effective defensive weapon for the lower tier of theater missile defense. ERINT was selected as the PAC-3 missile by the Army in February 1994 and approved for EMD by the DAB in May 1994. The missile will enter Engineering and Manufacturing Development (EMD) in the fourth quarter of FY 1994. Hardware and software testing will be performed, followed by integrated system performance demonstrations culminating in EMD flight tests against threat targets in a stressing environment.

The ERINT program will demonstrate a small, agile, hit-to-kill missile that will provide an asset defense against incoming maneuvering and non-maneuvering TBMs. A secondary objective of the program is to provide defense against air breathing threats. The missile combines several state-of-the-art technologies, including an on board active millimeter wave seeker that provides endgame guidance, advanced flight control technologies for agility in terminal maneuvers, lethality enhancement technologies, and a lightweight composite case solid rocket motor. The ERINT missile has been designed to integrate easily with existing air and missile defense capabilities such as Patriot, and is a technology capable of integration into the Navy AEGIS weapon system.

The ERINT flight test program is comprised of eight flight tests during FY 1992-1994. The hit-to-kill technology was proven with two successful guided test flights against ballistic missile targets. An additional guided flight is planned against an air breathing threat.

PROJECT NUMBER: 2209
PROJECT TITLE: Arrow Continuation Experiments (ACES)
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	61,424	52,400	45,000

PROJECT DESCRIPTION:
The Arrow Continuation Experiments (ACES) Program is a U.S.-Israeli initiative designed to provide Israel with a basis for an informed engineering and manufacturing decision for an area tactical ballistic missile defense capability and to provide the U.S. with technology information and data. This program is a follow-on demonstration phase for Arrow interceptor development. Critical lethality tests are being conducted in the initial phase of this program using the Arrow I missile developed during the Arrow program. An Arrow II missile is being designed and will be tested for an increased engagement envelope. If successful, the Arrow II will satisfy the Israeli requirement for an interceptor for defense of military assets and population centers and will support U.S. technology base requirements for new advanced antitactical ballistic missile technologies that could be incorporated into the TMD layered defense system.

The Arrow Deployability Program beginning in FY 1994 will pursue the research and development of technologies associated with the deployment of the Arrow system. This effort will include three system-level flight tests of the Arrow II interceptor and launcher supported by the Israeli developed fire control radar and battle management control center, and studies to define interfaces required for Arrow system interoperability with U.S. TBM systems. Prior to obligation of funds to execute Arrow Deployability Program research and development (R&D) efforts, the President will certify to the Congress that a Memorandum of Agreement (MOA) exists with Israel for these R&D projects, that each project provides benefits to the U.S., that the Arrow missile has completed a successful intercept, and that the government of Israel continues to adhere to export control pursuant to the MTCR.

PROJECT NUMBER: 2210
PROJECT TITLE: THAAD
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0604216C RDT&E	434,658	495,690	457,290

PROJECT DESCRIPTION:
The Theater High Altitude Air Defense (THAAD) system is being designed to negate Theater Ballistic Missiles (TBM) at long ranges and high altitudes. Its long-range intercept capability will make possible the protection of broad areas, dispersed assets, and population centers against TBM attacks. High altitude intercepts will allow an effective defense against Maneuvering Reentry Vehicles (MARVs) and greatly reduce the probability that debris and chemical or biological agents from a TBM warhead will reach the ground. The combination of high altitude and long-range intercept capability may also provide multiple engagement (shoot-look-shoot) opportuni-

ties. THAAD will be interoperable with both existing and future air defense systems and other external data sources (e.g., space based sensors). This netted and distributed BM/C^{3}I architecture will provide robust protection against the entire TBM spectrum.

The THAAD element includes missiles, launchers, BM/C^{3}I units, and support equipment. The Theater Missile Defense Ground Based Radar (TMD-GBR) element will provide fire control and surveillance for THAAD as well as for other TMD systems. The THAAD element, combined with the TMD-GBR element, forms the THAAD system. The THAAD system will be C-130/C-141 transportable. Furthermore, an engineering analysis for adapting the THAAD system in a cost and operationally effective manner for a sea based defense is being conducted.

The THAAD demonstration/validation (Dem/Val) program includes an option for building a prototype "battery" called the User Operational Evaluation System (UOES). It will consist of 40 missiles with 4 launchers, 2 BM/C^3 units, 2 TMD-GBRs and support equipment. The UOES will be used primarily for early operational assessment, but will also be available for use during a national emergency. This approach provides near term improved TMD capability and lowers the risk of subsequent phases of the acquisition cycle. The objective system will be fielded in the 2001 time frame.

PROJECT NUMBER: 2212
PROJECT TITLE: Corps SAM
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	20,000	17,725	30,590

PROJECT DESCRIPTION:
The Corps SAM system is an element of the Theater Missile Defense (TMD) architecture that would be deployed and operated by both the Army and Marine Corps. It is the critical lower tier component of the active defense pillar which is required to provide low-to-medium altitude air defense (AD) and theater missile defense (TMD) in the context of the early entry, movement to contact, and decisive operations of Army Operations and the rapid force projection needs of the U.S. national war fighting strategy. As such, it would protect critical fixed assets in the echelons above corps and corps rear and mobile assets of the maneuver forces located in the expanding forward area of the corps. Corps SAM will be small, lightweight, and modularly configured in order to be highly transportable and mobile compared to current AD/TMD systems. It will provide 360-degree defense against multiple and simultaneous attacks by a wide variety of tactical missiles and Air Breathing Threats (ABT) that employ both conventional and unconventional warheads. Specifically, these threats include short and very short-range tactical ballistic missiles as well as cruise missiles, unmanned aerial vehicles, and both fixed and rotary wing aircraft. These offensive and Reconnaissance, Intelligence, Surveillance, and Target Acquisition (RISTA) threats are primarily targeted against corps assets and operate behind, above, and beyond forward area AD. Corps SAM will be compatible and interoperable with other Army, Service, and Allied systems expected to participate in joint/combined operations.

PROJECT NUMBER: 2213
PROJECT TITLE: Sea Based Area TBMD
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0208060C PROC	0	14,496	11,287
0604216C RDT&E	154,000	179,543	240,224

PROJECT DESCRIPTION:
The Theater Ballistic Missile (TBM) threat is present and growing in terms of both weapon proliferation and sophistication. Sea based assets can provide a significant contribution to Theater Ballistic Missile Defense (TBMD) objectives. Development of a sea based theater ballistic missile defense capability takes advantage of the attributes of naval forces including overseas presence, mobility, flexibility, and sustainability in order to provide protection to debarkation ports, coastal airfields, amphibious objective areas, Allied forces ashore, population centers, and other high value sites. Additionally, in many cases, sea based assets will provide the only means to establish an initial TBM defense for the insertion of additional land based TBMD assets and other expeditionary forces in an opposed environment. The sea based area TBMD project builds on the $42B national investment in AEGIS ships, weapon systems, and missiles. Two classes of ships continue to be deployed with the AEGIS combat system: the CG-47 Ticonderoga Class cruisers and the DDG-51 Burke Class destroyers. The Secretary of Defense's Bottom-Up Review (BUR) in FY 1994 established Sea Based Area TBMD as one of the core major acquisition programs for Theater Missile Defense. Project costs and schedule reflect this priority. The sea based project is dependent upon receipt of the requested funding. Navy Theater Air Defense (TAD) programs were consolidated under a new Program Executive Officer (PEO) organization to include TBMD, Cooperative Engagement Capability (CEC), ship self defense, and Battle Management/Command, Control, and Communications (BM/C^3).

Attributes of a Sea Based Area TBMD capability supported by the requested funding include:

- Modifications to the AEGIS Combat System (ACS) to include computer program and equipment modifications to the command and decision system, the AEGIS display system, and the radar system (AN/SPY-1B/D).

- Modification to the Navy STANDARD Missile (SM-2 Block IV) to develop the SM-2 Block IVA which will be capable of engaging TBMs in the endoatmosphere. First unit equipped (FUE) is scheduled for FY 1999.

- A goal of fielding a user operational evaluation system (UOES) consisting of the SM-2 Block IVA and selected ACS modifications in FY 1997 if required to counter an existing threat.

PROJECT NUMBER: 2300
PROJECT TITLE: BM/C^3 Technology
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	130	0	0
0603217C RDT&E	23,197	56,500	59,000

PROJECT DESCRIPTION:
The battle management, command, control, and communications (BM/C^3) program will develop BM/C^3 technologies to support increasingly capable rapid prototyping and contingency deployment options. The primary objectives of the BM/C^3 technology readiness program strategy are: (1) integrate interceptors, sensors (Ground Based Radar and Space and Missile Tracking System), and operators to provide end-to-end capability to perform the functions needed to counter the ballistic missile threat to North America; (2) reduce contingency deployment lead times for a National Missile Defense (NMD) system, which is operable, even with a limited capability, and interoperable with necessary external systems and missions; (3) facilitate refinement of mature NMD BMD CONOPS, and operational requirements to ensure the proper end-to-end behavior is implemented. This technology program will leverage and grow from existing communications, command and control, and processing capabilities.

PROJECT NUMBER: 2308
PROJECT TITLE: HAWK System BM/C^3
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0208060C PROC	0	3,831	5,131
0604216C RDT&E	29,629	26,800	23,000

PROJECT DESCRIPTION:
This project will provide a basic tactical missile defense (TMD) capability for the Marine Corps to provide for a point defense of vital assets in the amphibious operating area of mature and contingency theaters. This TMD capability will be accomplished through product improvements to the AN/TPS-59 radar and the HAWK missile system. Additionally, the development of the Air Defense Communications Platform (ADCP) is included in this project. This project was not affected by the Bottom-Up review (BUR)

The AN/TPS-59 modifications include adding a ballistic missile detection and tracking capability, increasing the detection probability on low Radar Cross Section (RCS) targets, and improving the overall system reliability and transportability.

The ADCP development provides the communications capability required to provide AN/TPS-59 cueing data to the HAWK system and to other interceptor systems via the Joint Tactical Information Distribution System (JTIDS).

The HAWK upgrades include processing changes to allow for remote cueing from theater sensors and software changes to perform ballistic missile engagements.

PROJECT NUMBER: 3101
PROJECT TITLE: Engineering/Integration Support
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	12,500	45,590	45,590
0603217C RDT&E	29,105	18,977	18,977

PROJECT DESCRIPTION:
Provides system engineering, integration and technical management of the Ballistic Missile Defense (BMD) program, including Theater Missile Defense (TMD) and National Missile Defense Technology Readiness Program (NMD/TRP) segments. This Congressional Descriptive Summary is a consolidation of the following FY 1994 System Engineering and Integration support projects: 2304, 3102, 3103, 3104, 3105, 3108, 3109, 3110, 3111, and 3112. These projects constitute the core BMD Systems Engineering program. In prior years, many of these individual projects were executed via separate contracts. As a result of the Secretary of Defense's Bottom-Up Review (BUR) in FY 1994, funding for the Systems Engineering and Integration activities were reduced to approximately 30% of the FY 1993 level; FY 1994 represents a transition year to a focus on TMD. FY 1995 represents a planned ramp-up from FY 1994; FY 1995 activities are 50% of the FY 1993 baseline level. The FY 1995 effort is consolidated under work performed through the Systems Engineering and Integration Contract (SEIC). Programs include: mission/threat/performance analysis, simulation and modelling, logistics supportability and producibility, and specialty engineering products to ensure overall system effectiveness, survivability, compatibility and interoperability. In addition, the effort coordinates development of cost-effective, mission critical software; identifies and develops critical measurement standards, unique to BMD requirements, which provide the scientific basis for measurement of BMD system performance parameters; integrates logistics support, to ensure operational readiness of BMD weapons systems; defines life cycle costs, schedule and performance risks; identifies critical technologies to enhance system performance in order to mitigate future threats; and identifies and tracks critical Producibility and Manufacturing (P&M) issues and risks. This effort is also responsible for: monitoring the U.S. industrial base capability and develops mitigation strategies for P&M issues, as well as an overall BMDO P&M strategy; development and application of the Surveillance Test Bed (STB), which provides a digital, multi-sensor simulation, inter-service data fusion capability. Develop and integrates Human-In-Control (HIC) command and control simulations (C^2 Sims) for the unified and specified commands and their components. These simulations provide critically needed capability to refine and validate TMD and NMD/TRP operational requirements and Concepts Of Operations (CONOPS). This aids the evaluation of alternative command and control architectures and related information architectures to the requirements allocation process.

PROJECT NUMBER: 3107
PROJECT TITLE: Environment, Siting, and Facilities

PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	5,606	5,606	5,606
0603217C MILCON	2,727	530	2,992

PROJECT DESCRIPTION:
Provide environmental impact analysis documentation and real property facility siting and acquisition support for the BMDO systems and technology projects. Plan, program, budget and monitor facility acquisition of Military Construction (MILCON) and RDT&E construction projects. Provide guidance and manage the Environmental Assessments and Environmental Impact Statement process, as applicable, for BMDO technology demonstrations and test and evaluation activities. Develop guidance for Executing Agents on facility siting and acquisition and environmental matters.

PROJECT NUMBER: 3201
PROJECT TITLE: Architecture and System Analyses
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	26,675	42,161	48,361
0603217C RDT&E	11,000	8,000	8,000

PROJECT DESCRIPTION:
This project performs systems analyses in three broad areas: (1) theater missile defense architectures, (2) alternative ballistic missile defense architectures and concepts, and (3) mission analyses and simulations.

The theater missile defense analyses involve a wide variety of boost phase intercept implementations, joint BM/C^3I architecture trades, attack operations concepts, functional studies for allied applications, plans and techniques for integration across theater missile defense pillars, and examinations of how new theater missile defenses will integrate into existing U.S. and allied air defense architectures.

The alternative ballistic missile architectures and concepts area conducts independent studies of element designs, architecture performance, alternative architectures and their performance, architecture costs, and insertion of emerging technologies into the system elements to reduce costs and increase effectiveness.

Mission analyses and simulations focus on definition of ballistic missile defense concepts; the impact of these concepts on international stability, deterrence, and arms control; and strategic and tactical effectiveness of proposed architectures.

This project includes funding in FY 1993 for project 3210. Project 3210 is not funded in FY 1994 or FY 1995.

PROJECT NUMBER: 3202
PROJECT TITLE: Operations Interface
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	0	2,522	2,522
0603217C RDT&E	4,373	1,530	1,530

PROJECT DESCRIPTION:
This project supports the operational interfaces that must be provided to both the systems acquisition community and the military operational community. For the acquisition community, this project supports preparations for and execution of the Defense Acquisition Board (DAB) activities for BMD systems. The project also provides analyses of acquisition policies, processes, and plans to develop effective, streamlined means for acquiring BMD systems. Analyses and simulations address system effectiveness of proposed BMD system architectures against ballistic missile threats to U.S. deployed forces, our Allies and friends.

PROJECT NUMBER: 3203
PROJECT TITLE: Intelligence Threat Development
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	8,050	8,050	8,050

PROJECT DESCRIPTION:
The purpose of the BMD Intelligence Threat Development project is to provide an up-to-date Intelligence Community validated threat description against which system specific threat driven specifications, lethality designs, and target objects are developed. The primary vehicle for providing these threat descriptions is the System Threat Assessment Report (STAR), which is updated and validated by the Intelligence Community annually under this project. The STAR provides a general assessment of these capabilities doctrine, equipment, and forces that potential adversaries could use to defeat or degrade the BMD system. In addition to the STAR, annexes, for each Major Defense Acquisition Program (MDAP), are provided and validated by the intelligence community each year. The annexes contain somewhat more information than the STAR and are system specific to each MDAP. The Intelligence Threat Development Program divides the threat into four major categories-Operational Threat Environment, Targets, and System Specific Threats, and Reactive Threats. The Operational Threat Environment category includes assessments of the operational, physical and technological environment and projects the effects of those developments and trends on mission capability out to the end of life cycle. The outputs often take the form of assessed limits on deployment and employment tactics or strategies for the use of pro-

jected threats in attack scenarios. The Targets category includes a projection of threat systems and the countermeasures that enhance their performance. This includes force structure, performance characteristics, limits on employment and control, and where available, sample signatures. The System Specific Threat category includes Reconnaissance, Surveillance, and Target Acquisition (RSTA); lethal and nonlethal threats; and regional integrated SST assessments. Both targets and SST are described up to four levels of detail. Level O is the highest level in terms of basic capabilities and country of origin. Level 1 provides the form, fit and function characteristics necessary to support system tradeoff studies. Level 2 is a very detailed design in which actual materials and structures are described for use in lethality studies and detail element designs. Level 3 is flight target designs with manufacturing blue prints for either signature or lethality testing. Additional analyses evaluate emission signatures, reflection signatures and dynamics signatures (trajectories and microdynamics), and the system specific vulnerabilities for strategic and theater elements of ballistic missile defense systems. The Reactive Threats are divided into high interest technologically feasible threats and theater missile defense threats. These analyses will provide detailed data for developing both theater defense systems and other ballistic missile defense systems.

PROJECT NUMBER: 3204
PROJECT TITLE: Countermeasures Integration
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	16,303	18,303	18,303

PROJECT DESCRIPTION:
The mission of the BMDO and Countermeasure Integration (CMI) Program is to stress BMD systems and architectures to ensure that deployed ballistic missile defense systems are robust to potential countermeasures which are within the means of anticipated adversaries. Included in this mission is a twofold responsibility. First, the CMI program supports the BMD threat development process by stimulating the examination and assessment of all credible counters to future deployed systems. Secondly, the CMI program provides the BMDO system designer with advance warning necessary for building preplanned improvements and program hedges into the design.

The BMDO CMI Program carries out its mission by pursuing the following objectives: review BMD systems for susceptibilities and identify potential countermeasures; determine credibility through analyses and tests; characterize credible countermeasures by providing designs and performance parameters; inform intelligence and system threat developers of potential countermeasures; and inform BMD system designers with advance warning of potential countermeasures.

The CMI Program uses three primary resource groups to execute the process of countermeasure identification, analysis, verification and assessment. These three resource groups are the Red Teams, laboratories, and strategic analysis groups. Red teams are formed and tasked to identify and analyze potential countermeasures to a BMD system architecture. The laboratories and the contractor are responsible for verification of the technical feasibility of potential countermeasures. The strategic analysis groups provide assessments of the reality of potential countermeasures within the total context of the adversary's environment. Through this framework, the CMI program is able to access an array of countermeasure evaluation resources from government agencies, national laboratories, and contractors.

PROJECT NUMBER: 3206
PROJECT TITLE: System Threat
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	6,890	6,890	6,890

PROJECT DESCRIPTION:
With the changing world situation and the projection of continuing proliferation of ballistic missiles, it is imperative that an accurate characterization of theater, national, and global threats be developed. The accurate specification and characterization of ballistic missiles and the appropriate development and integration of scenarios using these characterizations is critical to: (1) the analysis of alternative ballistic missile defense architectures; (2) the performance assessments of potential technology applications; and (3) the operational performance evaluations of candidate designs. The threat specifications and characterizations must be based on accepted intelligence community threat projections or realistic estimates of technological/operational innovations; be traceable back to objective and quantifiable analyses; and be supported by the using organizations. These threat projections, described in engineering terms and parameters, must be used by all BMDO agencies to ensure that results can be compared and contrasted.

The System Threat development project is an integral part of BMDO's three-part Threat Program. The System Threat Project uses as a baseline the System Threat Assessment Report (STAR) developed under the Intelligence Threat Development Project (#3203) and incorporates likely adversary countermeasures identified in the Countermeasures Integration Project (#3204). The System Threat Project adds system specific engineering characterization details described in the form of scenarios characterizing particular timing, targets, and tactics.

The System Threat Project achieves its objectives through cooperative efforts with the Intelligence Community, BMD system developers and supporting contractors. Using the expertise available through these entities, the System Threat Project:

(1) Identifies user needs for threat scenario descriptions;

(2) Identifies analyses needed to fully specify and characterize the threat missile systems, penetration aids, tactics, etc., and ensures the analyses is done;

(3) Provides the analysis results to all interested agencies for review and comment;

(4) Addresses critical threat issues which arise during the analysis process;

(5) Ensures all supporting agencies' views on threat issues are fully aired;

(6) Reviews, approves, produces, and distributes all System Threat Scenario Descriptions;

(7) Produces threat computer tapes and supporting documentation for use by the development and acquisition communities.

The System Threat Scenario Description Documents are presented to the BMDO System Design Board (SDB) for endorsement and configuration control.

PROJECT NUMBER: 3211
PROJECT TITLE: C⁴I Concepts Operations Analyses
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0604216C RDT&E	12,567	33,500	20,129
0604225C RDT&E	0	555	16,166

PROJECT DESCRIPTION:
C^4I, in the context of this project, is defined as all those command, control, and intelligence functions serviced by computers and communications systems beyond weapon control functions. This project assumes theater missile defense is an extension of the traditional air defense. As such, TMD will integrate into the existing theater air defense command and control structure. This project contains those upgrades required to meet the dynamics of ballistic missile defense in a theater air defense structure. Integration of sensors and communications systems will provide enhanced support, not only to active defense, but to attack operations and passive defense as well.

This effort includes analyzing known and planned unified theater air defense CONOPS and C^4I architectures; identifying information types and information flows based on stratagems and use; determining the optimum architecture via trade studies; prototyping of a tactical operation center to integrate Army TMD assets; initiating upgrades to Air Force command and control nodes; making improvements for the dissemination of attack warning, target acquisition, cueing and command information to battlefield systems; and developing a standard message set that will support the TBM mission.

PROJECT NUMBER: 3300
PROJECT TITLE: Test & Evaluation Support
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	91,748	163,855	167,900
0603217C RDT&E	186,741	103,097	83,478
0604216C RDT&E	37,952	34,850	37,510

PROJECT DESCRIPTION:
This effort provides for BMDO planning oversight and coordination of integrated Test and Evaluation activities and interelement, as well as interservice Test and Evaluation efforts. Provides Independent Test Evaluation of systems, technology programs and special reviews. Provides for test infrastructure including: The National Test Facility; The Advanced Research Center; Simulation Center; common National Test Bed support; common ground test facilities; high fidelity models and simulation to support system development testing and evaluations including international cooperative with the United Kingdom, France, Israel, and the SHAPE Technical Center (STC); common range support, range upgrades; special test equipment and range instrumentation; Targets, test support assets; and test data documentation, management and storage facilities. Using mobile test assets such as the Airborne Surveillance Testbed (AST), provide critical signature and functional data essential to risk reduction and design of future optical surveillance systems.

This project includes funding in FY 1993 and FY 1995 for 3312 and funding in FY 1993 and FY 1994 for 3308. Project 3314 is funded in FY 1993 and FY 1994 and funding for Operational Testing (3314) in the out years will be transferred from Program funding lines to 3314 for execution. The following projects are funded in FY 1993-FY 1995: 3301, 3302, 3303, 3304, 3305, 3306, 3307, 3308, 3309, 3310, 3311, 3312, 3313, and 3314. This CDS also provides for the development of the TMD System Exerciser. This integration tool will assist in performing system level interoperability testing.

PROJECT NUMBER: 4000
PROJECT TITLE: Program Management
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603216C RDT&E	11,026	7,834	17,805
0603217C RDT&E	43,360	47,996	47,581
0603218C RDT&E	198,802	215,233	223,077

PROJECT DESCRIPTION:
This project provides program management, system engineering, and program control support common to all other projects within these PEs. Program management tasks include BMDO and Executing Agent central management functions, including those that support the Office of the Director, Ballistic Missile Defense Organization and his supporting staff located within the Pentagon. Typical system engineering tasks include review and analysis of technical project design, development and testing, test planning, assessment of technology maturity and technology integration across BMDO projects; and support of design reviews and technology interface meetings. Program control tasks include assessment of schedule, cost, and performance, with attendant doc-

umentation of the many related programmatic issues. This project supports funding for personnel and expenses for Temporary Duty (TDY) travel, training, rents, communications, information management, utilities, printing, reproduction, supplies, and equipment.

PROJECT NUMBER: 4302
PROJECT TITLE: Technology Transfer
PROGRAM ELEMENT/FUNDING ($ in Thousands):

	FY 1994	FY 1995	FY 1996
0603217C RDT&E	2,862	2,862	2,862

PROJECT DESCRIPTION:
The Technology Applications Program was established in 1986 to make SDI, now BMD, technology available to federal agencies, state and local governments, and U.S. business and research interests. The objective of this program is to develop and support the transfer of BMD derived technology to Department of Defense applications as well as to other federal, state, and local government agencies, federal laboratories, universities, and the domestic private sector.

This project includes funding in FY 1993 for project 4305. Project 4305 is not funded in FY 1994 and FY 1995.